

SEA-MANS

PRACTICE,

1751. 12. 12

CONTAINING

A FUNDAMENTAL PROBLEME

IN

NAVIGATION:

Experimentally verified :

Namely , Touching the Compass of
the *Earth* and *Sea*, and the Quantity of a
Degree in our *English* measure.

Also an Exact Method or Form of Keeping a
Reckoning at Sea, in any kind or manner of Sailing.

With certain *TABLES* and other *Rules* useful
in *Navigation*, As also in the *Plotting* and *Surveying*
of *Places*. The *Latitude* of the Principal Places in
ENGLAND. The finding of *Currents* at *Sea*, and
what Allowance is to be given in respect of them.

THE SEVENTH EDITION.

By *Richard Norwood*, Reader of the *Mathematicks*.

London, Printed by *W. Godbid*, for *George Hurd*, and are to be
sold at his Shop at *St. Magnus Church*, at the inner end of
London-Bridge, near *Thames Street*. 1687.



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To the Right Honourable.

ROBERT

Earl of *WARWICK*,

Baron of *LEES*, &c.

Right Honourable,



Lthoug the knowledge and practice of the Art of Navigation be of late years grown to a far greater Perfection, than it can appear to have had in any former Age; and by that means, the World and all the parts thereof have been further discovered, yea, Sailed round about: the Traffick and Entercourse of several Nations, how remote soever, facilitated. Knowledge in divine and humane things divulged: and (which as I conceive is of most importance, seeming as yet to be the principal scope of the Divine Providence in discovering these Mysteries) the light of the glorious Gospel of *Christ*, being the mighty power of God unto Salvation, is extended to those silly Captives of Sathan in *America*, by means of those many Plantations we have amongst them: which Plantations (even from their first breathing) have received no small furtherance from your Noble favour and bounty, as I know by my own Experience in that where sometimes I was, and have understood no less by others in the rest.

The Epistle Dedicatory.

Yet notwithstanding this notable growth and dayly exercise of the Art of *Navigation*, it still remains imperfect in some points. For whereas the practice thereof doth especially consist in the knowledge of *Latitudes*, *Courses*, and *Distances*; the way of finding *Distances* at Sea, namely, by the *Log* and *Line*, is rather opinio-
native and conjectural then certain, being grounded upon this supposition, that the compass of the World in any great Circle is 21600 *Italian* miles (as they call them) and that such an *Italian* mile contains 1000 Paces, and every of those paces five *English* feet: and according to these measures they divide their *Log-line*, and keep their account of the ships way at Sea.

Having therefore by an Experiment which I made a year since, found more neerly the compass of the Earth, and the quantity of a Degree on the same in our known measures, and applyed to use in *Navigation*, in this Treatise following: and further added some other such things as I conceived to be wanting in the practice of that Art; I have presumed to present it to your Lordship, as well because by your knowledge in *Navigation*, and the experience you have had in your Honorable enterprises at Sea, you are well able to judge of it: as also being confident that according to your noble disposition you will favourably accept thereof, though otherwise of it self unworthy. The most High God ever blessed and glorious, multiply unto your Honour all his blessings in *Christ Jesus*.

Your Honours in all due Observance,

RICHARD NORWOOD.



To the Reader.

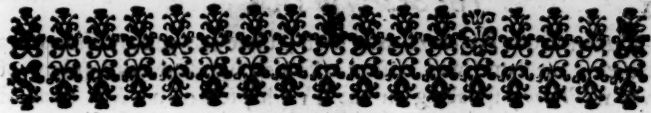
THE Circuit of the Earth and Sea (as the circumference of every Circle) contains 360 Degrees, by which degrees the distances thereon are measured, so that the knowledge of the quantity of such a Degree in our known measures, is a fundamental principle in Cosmography and Navigation, as upon which is grounded the reckoning of the ships way or distance run. For though a Mariner being in his Voyage on the vast Ocean, have sometimes three things to certify him where he is, and how to shape his course to his desired Port, namely, his Latitude, Course and Distance, and sometimes a fourth; namely, some near conjecture of his Longitude by the Variation, or otherwise; yet oftentimes (as in close weather) he hath nothing but his course and distance; otherwhiles only his Latitude and Distance is his chief guide in sailing with his intended Port. I know it is usual to allow near 7 Fathoms $41\frac{1}{2}$ feet to a knot, and so many of these knots as run out in half a Minute, so many miles they account the ships way to be in an hour. And if in half a minute she run $41\frac{1}{2}$ feet, then in 60 minutes, or an hour, she runs 5000 Feet, and thus they account 5000 English feet, or 1000 Paces to be a mile, and 60 of those miles to be a Degree, such as the whole circumference in any great Circle is 360. But how is this known to be true? If it be answered, that it is known to be so by Experience, then I would know further by what Experiment this was found to be so? Where, and by whom made? I press this so much the rather, because I am persuaded we have at this day as many excellent Navigators in this Kingdome, and as great Voyages performed, as from any other place in the world, and I should be glad to hear of the experimental resolution of this Problem by some of them, though it were but in running eight or ten degrees near the Meridian: for so I doubt not but that which I have here written thereof would receive further confirmation and better entertainment than haply it will now, being so much different from the common opinion, and the Arts of Navigation and Cosmography would be much more perfected in short time. For one error (as a fruitful Mother) is oftentimes the cause of more, and so removing of one is the occasion of removing others, especially, when they do mutually support one another: As we shall here shew how the Error in the Projection and use of the Common Sea-chart, is supported by this Error of accounting only 300000 of our Feet to a Degree; and this in like sort upheld by that, so that they will stand or fall together. And surely that had fallen long since, being so manifestly convinced; if it had not been upheld by this. For the confuting of that, (I mean the common Sea-chart)

To the Reader.

it was sufficient to know that the Earth and Sea make one Spherical body, but in disproving and rectifying this, it is necessary to know moreover what is the quantity of that Spherical body: and to that end it was necessary to make a sensible application of our known Measures, to a determined part of the whole, that so the quantity of that determined part being known, and the proportion thereof to the whole, the quantity of the whole might also be discovered. And this I have endeavoured in the experiment following, which if I have not handled so exactly in all points as some would desire: That requiring more time and charge (then I could well bestow) yet I doubt not but it will be found that I have come very near the Truth. Some happily will censure me, for being myself at the Expence to make such an Experiment, But I was as frugal in it as I could, adding pains and industry to save expence, I came up in ten or eleven dayes, and had other necessary occasions to lead me from the one place to the other, and did this as a thing falling opportunely in my way. But indeed (as in all other parts of Learning) so in the Mathematicks, especially in their application, or middle Mathematicks (as some call them,) it is necessary with Speculation to joyn Actual and Experimental practices; the former being empty and uncertain without these. It is true, that the Mathematicks afford large fields of delightful Speculations, wherein a man might walk far with much pleasure: But if from so many fair Flowers he bring home no honey, or from such large fields no sheaves: I mean, if he bring not those Speculations to some usefull practices, neither himself nor others are like to receive much fruit by them. But this indeed cannot be effected without more labour and difficulty, yet sometimes it requires Mechanical and bodily exercises, which some esteem too mean and unworthy to stoop unto. But for mine own part, I acknowledge to have had my living and maintenance by the Mathematicks, and not by Speculation only, but rather by my practice therein; and therefore also I desire (what in me lies) to make them fruitful to myself and others: And to that end have spent in some principal parts of the Mathematicks, near as much time and means in experimental Practices and Conclusions, as in the Speculation. Moreover, considering that this particular Experiment was proposed above thirty years since, by our Country man Mr. Edward Wright, to invite some to the trial of it, as a thing which he would have done himself, if he had found such surerance and opportunity as he desired, which it seems he did not, nor any other since that time: Rather then so noble and so necessary a Problem should longer rest unresolved, I took the opportunity offered, hoping it may be an occasion to bet on some others to do the like. This with some other things which I conceived to be wanting in the practice of Navigation, I have handled in this ensuing Treatise, which I commend to your friendly acceptance; Farewell.

July the first, 1635.


THE



THE SEA-MANS Practice.

CHAP. I.

*The common opinion touching the Compass of the Earth,
and quantity of a Degree of the same.*

T is a common received opinion in *England*, (and the like is in other places) that allowing 5 of our *English* feet to a Geometrical pace, 1000 of those paces make a *Italian* mile, and 60 of those miles in any great Circle upon the Spherical Surface of the Earth or Sea make a Degree; and thus it is supposed, that a Degree contains 60 miles, or 60000 paces, or 300000 of our *English* feet, and by such miles do Mariners in their Voyages by Sea keep their Reckonings: And because the whole circumference of a Circle is 360 Degrees, therefore the compass of the Earth, according to this opinion should be 21600 such *Italian* miles, or 21600000 paces, or 108000000 of our *English* feet. Whence this opinion came, or upon what experiment it should be grounded, I cannot certainly say; It may seem to be taken, or rather mistaken

mistaken from *Ptolomy*, who saith, there are 500 *Stadiums* in a degree, the same was before affirmed by *Marinus Tirinus*, of whom *Ptolomy* speaking in the 11 Chapter of his first Book of *Geography*, hath these words, *Sed in hoc quoque recte sensit partem unum qualium est circulus maximus tricentorum sexaginta, quingenta in terra constitutere Stadia, id enim confessis dimensionibus consonum existit.* Now a *Stadium* not only amongst the *Greeks*, but as appears by *Herodorus*, amongst all other Nations of *Asia* and in *Egypt*, did consist of 600 feet, or 100 *Orgyas*, an *Orgia* containing six feet or four cubits, as our fathom doth: the same is also testified by *Snidas* and others: So that a Degree containing 500 *Stadiums*: and every *Stadium* 600 feet, it follows that a Degree must contain 300000 feet, exactly agreeing in number with the common received opinion in *England*, which therefore may seem to be hence derived, and would also receive much confirmation hereby (he being an Authour of such approved credit) if it could be approved that our *English* feet were exactly equal to the *Egyptian* or *Alexandrian* foot, where *Ptolomy* wrote. Otherwise that being true, that so many of their feet make a degree, it will follow, that if ours be greater, there be fewer of them contained in a Degree; if lesser (as undoubtedly they are) there must be more of them contained in a Degree.

Philander in his Commentary upon the third Chapter of the third Book of *Vitruvius*, hath expressed the quantity of the ancient *Roman* foot, where (by a competent allowance for the shrinking of the paper being printed wet) it may probably be gathered that it was something longer than our *English* foot. But the *Alexandrian* and *Egyptian* foot was much greater, for according to *Heromechanicus*, 5 *Alexandrian* feet were equal to 6 *Roman* feet: seeing then the ancient *Roman* foot was something greater than ours, the *Alexandrian* foot must needs be much greater than ours. So that whereas *Ptolomy* saith there are 500 *Stadiums* in a degree, and as we have shewed a *Stadium* did consist of 600 feet, these being *Egyptian* or *Alexandrian* feet, as it is most probable, being the place where *Ptolomy* lived; there must be a far greater number of our feet in a *Stadium*, and so in a degree, whence

it is evident, that there is no sufficient footing for this common opinion in the assertion of *Ptolemy*.

Neither doth the practice and experience of Mariners in their Voyages at Sea prove it; for there is no reckoning or experiment at Sea set down by any (that I have seen) to confirm it. And though it be true, that in sailing between two places that lie neer to one and the same Parallel, they ground their reckoning chiefly upon this supposition, that 300000 of our English feet make a Degree, yet can they seldom or never by those reckonings discern the Error, the rather for that they have been and for the most part are still kept upon the Plain or Common *Sea-Chart*, which makes a Degree in any Parallel equal to a Degree in the Equinoctial; and so makes a Degree in any Parallel to contain 300000 feet; And it is true, that in some Parallel a Degree doth contain only 300000 of our English feet; namely, about that Parallel which is in Latitude 35 degrees (as we shall further shew hereafter) neer unto which have the principal of our Eastern and Western Voyages been made. And thus, though this opinion of 300000 feet in a Degree, and the projection of the *Common Chart* be both erroneous, yet because the error of the one doth something save the other, they could not be so easily discerned by Experience only.

This opinion of 300000 English feet to a Degree, may seem also to be something confirmed by an Observation made by our Countrey-man Master *Edmund Wright*, upon Mount *Edgcumbe* neer *Plimouth*, of the Semidiameter of the Earth, which he hath set down in his Book, *Of the Correction of Errors in Navigation*, Chap. 15. where he finds the Semidiameter to be 3212621 of our English feet; which is not to be denied, that in a Degree of a Great Circle of the Earth, there should not be full out 320000 of our feet; but the way by him thus used, though it was very fit for the end whereunto he there applies it; namely, to find the dipping or depression of the apparent Horizon beneath the truth, according to the height of the eye above the water; yet will it easily be granted to be

no exact way for finding the *Semidiameter*, and consequently the Circumference of the Earth, or the quantity of a Degree on the same; and so he says there, that he used that way, because he wanted opportunity to put it in practice a more exact way. Wherefore for the further Satisfaction of my self and others in this Point, and chiefly for the necessary use it hath in the Practice of *Navigation*, I have made the Experiment following, that so the quantity of a Degree, and of the whole Compass of the Earth might at least-wise be nearly known in our *English* measures.

CHAP. II.

An Experiment made for finding the quantity of a Degree, and so of the Circumference of the Earth and Sea in our known measures.



Having occasion to be in the City of *York*, about the beginning of *June*, Anno 1635. I made there several Observations of the Meridian Altitude of the Sun, the last of which was made the eleventh day of *June*, the Skie was every of those dayes something over-cast at noon, yet not so much but that an Observation might be made to near scantling: And because the last of those Observations is most fit for the present occasion, and that day was as clear as any of the other, we will here especially make use of that, being as followeth.

Upon the eleventh of *June* 1635. I made an Observation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an arch of a *Sextant* of more than five foot *Semidiameter*, and found the apparent Altitude of the Sun that day at noon to 59 degrees 33 minutes.

I had also formerly upon the eleventh day of *June*, Anno 1633. observed in the City of *London*, near the Tower, the appa-

apparent meridian Altitude of the Sun, and found the same to be 62 deg. 1 min.

And seeing the Sun's declination about the eleventh day of *June* 1633, and upon the sixth day of *June* 1633, was one and the same without any sensible difference; and because these Altitudes differ but little, we shall not need to make any alteration or allowance, in respect of Declination, Refraction, or Parallax: Wherefore subtracting the lesser apparent Altitude; namely 59 degrees 33 minutes, from the greater 62 degrees 1 minute, there remains 2 degrees 28 minutes, which is the difference of Latitude of these two Cities; namely, of *London* and *York*.

Also by the aforesaid Observation made in *York*, it appears, that the Latitude of that City is 53 degrees 58 minutes almost.

But to our purpose; Coming at that time from thence to *London*, I further found by measure, that the Parallel of *York* is from the Parallel of *London*, 9149 Chains; every Chain being six Poles, and every Pole 16½ of our English Feet; that is, every Chain ninety nine Feet. (After what manner I found this to be so, we shall further express hereafter:) But thus, as I say, I found that *York* is more Northerly than *London*, by 9149 Chains: And before, we have noted that these two places differ in Latitude 2 degrees 28 minutes: therefore it follows, that 2 degrees 28 minutes of the meridian on the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of these Chains are contained in one Degree, we may find that by the Rule of Proportion, first reducing the Degrees into minutes, and then say,

If the difference of Latitude give such a number of Chains.

Then one Degree, that is

gives of such Chains

and somewhat more, namely, five Feet, which reduced into Feet, make 367196; that is, 367200 Feet in a Degree, lacking four Feet, which here we regard not.

148 <i>or. ar.</i>	7.82974
9149	3.96137
60	1.77815
3709	3.56926

Thus then according to this Experiment, it is evident that one degree of a great Circle measured on the Earth, is near 367200 feet, which in our Poles of 16 $\frac{1}{2}$ feet, is 2254 Poles, and about one half, and these reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles; and lastly, these reduced into our *English* miles of eight Furlongs to a mile, make 69 miles, and 4 Furlongs, 14 Poles, that is 69 $\frac{1}{2}$ miles and 14 Poles in a Degree.

And hence according to the most approved *Hypothesis* of the *Sphericity* of this *Terrestrial Globe*, we may find the compass of it, as followeth. But first, you may note, that we speak not here of the compass of the Earth in any Parallel or lesser Circle described upon any side thereof (that being various according to the different distance of those Circles from their Poles) but of the compass taken in the middle or greatest thickness of the Globe, namely, in any great Circle, such as divide the whole Globe into two equal parts, of which kind are the Equinoctial and all Meridians, &c. this being properly the *Perimeter*, or Compass of a *Spherical Body*.

Now seeing a Degree is the 360 part of the circumference of a Circle (for any Circumference being divided actually, or by supposition into 360 equal parts, those parts are called Degrees) if we can find how many Feet, Paces, Miles, or other known measures are contained in one of those Degrees, then shall we easily conclude how many of the same known measures are contained in the whole Circumference: But by the former Experiment we find, that in one Degree of great a Circle on the Spherical Superficies of the earth, there is contained 367200 Feet; therefore it is evident, that 360 times 367200 feet is the Compass of the whole; wherefore multiplying 367200 by 360, the Product is 132192000 feet, which reduced into Poles, is 8011636, and these reduced into Furlongs, are 200290 Furlongs 36 Poles; and lastly, these reduced into Miles are 25036 *English* miles, and somewhat more for the circuit of the Earth and Sea.

If further we desire the Diameter and Semidiameter of the Earth

Earth, forasmuch as is proved by *Archimedes*, that the proportion of the circumference of a Circle is to the Diameter thereof, almost as 22 to 7: Therefore by the Rule of Proportion, as 22 to 7; So is the Circumference of the Earth, to the Diameter thereof: So that multiplying the Circumference of the Earth, namely, 132192000 feet by 7. and dividing the Product, namely, 925344000, by 22 the quotient, namely, 42061091 is the Diameter of the Earth in Feet, the half whereof, namely 21030545 feet, is the Semidiameter of the same, being 21 millions of feet, and somewhat more: these reduced into *English* miles, as before we did the Circumference, shew the Diameter of the Earth to be 7986 miles, and somewhat more, and the Semidiameter 3983. And thus we have the Circumference, Diameter, and Semidiameter of the Earth, as also the quantity of a Degree of the same Circumference in known measures of Feet, Furlongs, and Miles, &c. There are only two things here, which may seem doubtfull; namely, the Experiment it self, and the *Hypothesis* of the Sphericity of this *Terrestrial Globe* consisting of the Earth and Sea, for these being admitted, the measures thence peduced as before, will necessarily follow.

Now touching the Experiment, I confess, that to have made it so exactly as were requisite, and in all points so as I shall shew in the Chapter following, would have required much more time and expence than mine ability would reach unto; Yet having made Observation at *York*, as aforesaid, I measured (for the most part) the Way from thence to *London*, and where I measured not, I paced; (wherein through Custome I usually come very neer the truth) observing all the way as I came, with a Circumferentor all the principal Angles of position or windings of the way, with convenient allowance for other lesser Windings, Ascents, and Descents) and these I laid not down by a Protractor after the usual manner, but framed a Table much more exact and fit for this purpose; as we shall hereafter shew; so that I may affirm the Experiment to be neer the truth.

Touching

Touching the *Hypothesis* that the Earth and Sea make one Spherical or round Body, it is generally agreed upon by all the principal Philosophers, Astronomers, Geographers, and Navigators, ancient and modern, some reasons demonstrative for the confirmation thereof may be these.

First, The Eclipses, especially of the Moon, which are caused by the shadow of the Body of the Earth being interposed between the Sun and the Moon, and for as much as this shadow doth fall upon the Moon, always and on every side circular, and so appears to us, it is manifest by the Opticks, that the Earth from whence it proceeds in a Spherical Body.

Secondly, Likewise the Eclipses of the Sun, which are caused by the interposition of the Moon between the Sun and those places where it appears Eclipsed; I say it could not be determined when and in what place such an Eclipse should appear, and where not, if the form of the Earth were not known; but seeing the places where such Eclipses happen, and where not, may be and are usually determined, and that upon this ground; that the Surface of the Earth is Spherical, it is thence also ratified to be a truth.

Thirdly, the Sun, Moon, and Stars do rise and set, and are upon the Meridian sooner to those that are resident in the Eastern parts, then to others more Westerly, and that in a proportion answerable to the roundness of the Earth, as the Planets and Stars are upon our Meridian at *London* sooner by almost four hours, than they are to those that inhabit *Summer Islands*, and the confines of *Virginia* and *New England*: And so in *East-India*, and other Eastern Regions, the Sun and Stars are sooner upon their Meridian then upon ours, which is manifest to be so, as by other reasons, so especially by the Eclipses of the Moon: for an Eclipse of the Moon hath not in it self any diversity of time, being at one and the same instant without respect of places, yet because in the Eastern parts the day is begun, and it may be far spent before it begin in places far Westerly, therefore such an Eclipse may appear to the Eastern Inhabitants towards the end of their night, which to the Western appears

pears in the beginning or middle of the same night with them, and so the difference will be more or less, according to the different distance of those places in Longitude.

Fourthly, Furthermore we see, that going or sailing to the Northwards, we have the Artick Pole and Northern Stars more elevated, and the Antartick Pole and Southern Stars more depressed, the Elevation Northerly increasing equally, with the depression Southerly, and either of them proportional to the distances which we go: The like happeneth in going to the Southwards. Besides the Oblique Ascensions, Descensions, Occultations, Emersions, and Amplitudes of Rising and Setting of the Sun and Stars, in every several Latitude, agreeable to the *Hypothesis* of the Earth's Sphericity, All which could not be so, if the Earth were of any other then of a Spherical form.

Fifthly, So if we stand upon the Sea-shore, and see a ship far off under Sail, making towards the Land, at first we see only the Top-sails or highest parts, and withall do manifestly behold the convex Superficies of the Sea, as it were raised and interposing her self between our sight and the Hull or lower parts of the Ship, till she approacheth nearer, and this uniformly, every ways alike, and proportionably to the several distances; which doth evidently demonstrate the Spherical roundness thereof.

Sixthly, And lastly, (to add no more) the Navigations of these later times make it apparent, those especially that have been made round about the World, as those two Voyages by our famous Countrey-men Sir *Francis Drake* and Mr. *Thomas Candish*, both which severally sailing from our Coasts to the *West-Indies*, and passing the Streights of *Magellane*, continued their course Westerly, till they came into those parts, which are from us to the East-wards; namely, to the *East-Indies*, and so sailed still Westerly till they came to *Cape Bon Esperance*, and thence returned into *England*: having sailed about the whole Terrestrial-Globe, they found nothing by their observations or Reckonings dissonant from the uniform Sphericity thereof
in

in all its parts. That they came short in the number of days, one; or reckoned the time of their absence less by one day and a night than they which remained at home; this further confirms the thing in hand.

Yet whilst we speak here of the Roundness of the Earth and Sea, we intend it not so strictly as if it were a thing turned round without any inequality in its Superficies: But as a Bowl or Ball though it have some dust or small grains of sand cleaving thereto, may still be said to be round: So though the Land, Hills, and Mountains be somewhat raised above the Spherical Superficies of the Sea, and if there should be also some Valleys or Bottoms more depressed; yet seeing the greatest of these inequalities have scarce any sensible proportion to the whole, we may well affirm the Whole to be round.

The relations made of the prodigious height of some Mountains, as to be 60 or 70 miles high, if it be understood of their perpendicular or direct height, are fabulous: the Mount *Atlas* recorded by some of the Ancients, to reach up almost to the Moon, and to be as it were a Pillar for the Heavens to rest upon, being measured Geometrically by *Eratosthenes*, the perpendicular or upright height from the top thereof to the Valleys beneath, was found not to exceed ten *Stadiums*, which of our *English* measures is little more than a mile and a quarter, a *Stadium* not much differing from our Furlong; and the like might be shewed of others.

But if we admit the highest Mountains to rise perpendicularly above the Spherical Superficies of the Sea two miles, yet seeing the Diameter or whole thickness of the Earth, is as we have before shewed 7966 miles, this exorbitancy or difference of two miles is of small moment; yea, if there were any Mountain eight miles in height upright, yet this compared with the whole thickness of the Earth, is little more than one thousand part thereof; therefore we may conclude, that this *Terrestrial Globe*, consisting of the Earth and Sea, is *Spherical*. We come in the next place to shew by what way of measuring we found the Parallel of *York* to be distant from the Parallel of *London*,

9149 Chains. And so how the distance of the Parallels of two Places may be exactly measured.

CHAP. III.

A most exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the same



Do the more fully set down the way of making this Experiment, that so I may give occasion to any who are so nobly minded for a publick good, as to be at that charge to make a further and more exact tryal thereof. Now then the best & perfectest way, is to observe so exactly as may be the Summer *Solstitial* Altitudes of the Sun at two places, so far distant asunder, and lying so near North and South each from other, with so direct and fair a way between them, as conveniently may be chosen: Suppose for example *Christ Church* and *Berwick*, or some other place in the furthest parts of *Scotland*, for the further these two places are each from other, the more perfectly may this business be performed. Then measure as truly as is possible, and set down in a Book, all the way between those two places, with all the Windings, Ascents and Descents that are therein, whereby with the help of the ensuing Table, you may easily and exactly find how much the one place is more Southerly than the other. For this purpose the *Plain Table* is not the fittest Instrument, but rather a *Theodolite* or *Perforator*, or some other of that kind, observing diligently the Variation of the Needle. The Chain may be six poles long, or rather 100 feet, and the Table fitted accordingly (but the Table following is for poles) if it should be much longer it would be too heavy.

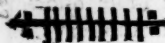
The High-ways are commonly crooked, yet because of sundry obstacles and impediments which are incident out of the way, and because a man cannot certainly at first direct himself the nearest and best way to the place intended, it would be expedient

pedient to measure the distance as aforesaid; First, in the Highways, leading from the one the other, and then in the nearest and best way that could be chosen between them; and so if any notable Error happen in the one, it may be discovered and amended in the other. The form which I observed in setting down the measures and angles, was according to this Example.

Deg.	Distance.	North.	South.	East.	West.
SE 31					
SE 20					
SE 13					
SE 13					
SE 13					
SW 02					
SE 05					

It is to be understood, that the Table here following was before calculated to serve instead of a *Protractor*, for a Circumferentor, or other Graduated Instrument, and for a Chain of three Poles, which for the most part I use; yet it may very well be applied to a Chain of six Poles, (as in this business it was) reckoning every Chain to be two, &c. And thus for every ten Chains of six Poles to a Chain, I make two strokes signifying two Changes or 20 Chains, and if there be any odd Chains, for those I set a figure in another line next below; and if moreover any odd Poles, whether one or two, for those I set another figure in a third line below.

Thus the last entrance before-going, being SE. 05 Degrees,

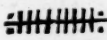
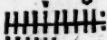
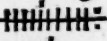
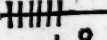
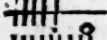
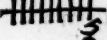


5
2

was from the South-part of the Meridian to the Eastwards, making

king an angle with the Meridian of 5 Degreeces, the nine strokes signifie nine Charges, or ninety Chains, the figure 5 signifieth five Chains, and the figure 2 two Poles. So that it is to be read thus; South-Easterly 5 Degreeces, 9 Charges 5 Chains, and 2 Poles; and the like is to be understood of the rest. But for the most part having liberty of ground, I end the measure of every line, either with a whole number of Charges, or at least of Chains.

And thus proceeding all day, towards the Evening; or when else I have time convenient, I reduce all these Distances, upon what Lines or Angles soever they be, to Distances of North or South, East or West, as here appears.

Deg.	Distance	North.	South	East.	West.
SE 31			2571	1545	
SE 2			2819	1026	
			1692	616	
			0169	062	
SE 13			2923	675	
SE 13			1754	404	
SW 02			1499		052
SE 05			2690	235	
			0149	013	
			0020	002	
Chains.	571		16286	4578	052
	2		0	52	
Poles.	1715		16286	4526	

We will explain the last, and to the rest may easily be understood: SE 5 deg. ||||| - 5.2. Here because I have SE. the numbers taken out of the Table must be put into the Columns entitled South and East. Then in the Table under 5 deg. I look for 9 Charges, and find against it 2690, and in the adjacent col. under the compl. thereof 235, and because SE 5 deg. is less than 45 deg. that is, nearer to the South than to the E. I put in the col. entitled South 2690, and in that entitled East 235; then again

in the same Tabular Column under 5 degrees, I find gainst 5 Chains, (cutting off a Figure; because 5 Chains is but the tenth part of 5 Changes) 149 to be put in the *South* Column, and 13 for the *East* Column.

Lastly, against 2 poles I find for the *South* Column 20, and for the *East* 2, and the like is to be understood of all the rest.

Now supposing this last to be a place, whose Distance and Situation from the first is required, I sum up the Columns severally, and of the *North* and *South* Columns subtract the lesser from the greater, and so of the *East* and *West* Columns; and so it will appear how much *North* or *South*, and how much *East* or *West* the last place is from the first.

As in this Example, we find the last place to be the Southwards of the first 1628 Poles, for the last figure may be cut off, being used in the Table, only for the more exactness, or may be made a Fraction, and so it is $1628\frac{6}{10}$ Poles, Likewise the last place is to the Eastwards of the first $452\frac{6}{10}$ Poles, and thus I proceed all the way.

Now touching the angles of ascent and descent of Hills and Valleys, to have observed them exactly, would have required more time and charge than I could of my self bestow; yet I made allowance for such of them as were of most moment, he that would observe them all, may either make two or three Columns more, or keep an account of them apart by themselves. But if he intend no further use of them, but to find the nearest distance, he need not set them down, but make allowance for them on the ground, keeping his distances intire without Fractions.

As, admit I observe the ascent from a Valley to the brow of a Hill to be 14 degrees above the Level or Horizontal Line, and that measuring, I find the distance to be 30 Poles; I turn to the Table, and under 14 degrees. and against 10 Chains, I find 2911, and 726, shewing that the Level or Horizontal distance from my Station to that Brow is only $29\frac{11}{100}$ Poles, and that the height of that Brow above the Level Line, is $7\frac{26}{100}$ Poles: But finding thus that the *Hypothensal* being 30, the
Base

Base or Level line is but $29\frac{11}{16}$ that is less by $\frac{1}{16}$, because I would avoid this Fraction, I add to the end of the foresaid measure of 30 poles upon a Level Line $\frac{11}{16}$ of a Pole, and then I may account my self distant from the place in the Valley where I made Obiervation 30 Poles in a *Level or Horizontal Line*, and so set down the distance without a Fraction: the like is to be understood of all other Ascents and Descents.



Here followeth the Table.

	1 deg	39 d.	2 d.	88 d.	3 d.	87 d.	4 d.	26 d.	5 d.	25 d.
1	300	5	300	10	300	15	299	21	299	26
	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	590	63	896	79
4	1200	20	1.00	42	1198	62	1198	84	1195	105
5	1500	26	1500	53	1497	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	147	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2628	95	2596	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	2993	210	2989	262
2	10	00	10	0	10	0	20	1	10	1
1	20	00	20	1	20	1	10	1	20	2

	6 d.	8 d.	7 d.	8 d.	8 d.	8 d.	9 d.	8 d.	10 d.	8 d.
1	295	31	298	36	297	42	296	47	295	52
2	597	62	596	74	594	84	592	94	590	104
3	895	94	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1490	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2089	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2354	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	2984	314	2978	366	2971	418	2963	469	2954	521
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11 d.	70 d.	12 d.	78 d.	13 d.	77 d.	14 d.	76 d.	15 d.	75 d.
1	295	57	293	62	292	67	291	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	274	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2631	608	2620	653	2610	699
10	2945	572	2934	624	2929	675	2911	726	2898	776
1	10	2	10	2	10	2	10	2	10	3
2	19	4	19	4	19	4	19	4	19	5

	16 d	4 d	17 d	1 d	18 d	72 d	19 d	1 d	10 d	70 d
1	288	8	287	88	285	593	284	90	282	103
2	576	166	574	177	570	186	568	196	564	206
3	865	250	861	264	855	279	851	294	846	308
4	1153	332	1148	352	1140	371	1135	391	1128	411
5	1442	413	1434	438	1426	463	1418	488	1410	413
6	1730	496	1721	526	1711	556	1702	586	1691	616
7	2019	580	200	611	1997	649	1986	684	1973	719
8	2307	663	2296	703	2282	743	2270	782	2255	822
9	2596	746	2583	791	2567	863	2552	880	2537	924
10	2884	827	2869	877	2853	927	2836	977	2819	1026
1	10	3	10	3	10	3	10	3	10	3
2	20	5	19	6	19	6	19	6	19	6

	21 d	59 d	22 d	68 d	23 d	67 d	24 d	56 d	25 d	65 d
1	280	107	278	112	276	117	274	122	272	127
2	560	215	556	224	552	234	548	244	544	254
3	840	322	834	337	828	351	822	366	816	381
4	1120	429	1112	449	1104	468	1096	488	1088	50
5	1400	537	1391	562	1380	586	1370	610	1360	634
6	1580	645	1569	674	1556	703	1544	732	1532	761
7	1960	752	1947	786	1932	820	1918	854	1904	888
8	2240	860	2225	899	2209	937	2192	976	2175	1015
9	2521	968	2504	1011	2485	1054	2466	1098	2447	1142
10	2801	1075	2782	1124	2761	1172	2740	1220	2719	1268
1	9	4	9	4	9	4	9	4	9	4
2	18	7	18	8	18	8	18	8	18	8

26 deg.

	26 d	64 d	27 d	63 d	28 d	62 d	29 d	61 d	30 d	50 d
1	270	131	267	130	265	141	262	143	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1058	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1182	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2649	1408	2624	1454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	8	18	10	18	10	18	10	18	10

	31 d	59 d	32 d	58 d	33 d	57 d	34 d	56 d	35 d	55 d
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	615
4	1028	617	1017	636	1007	653	995	671	983	688
5	1285	772	1272	795	1258	817	1243	838	1228	860
6	1542	927	1526	954	1510	980	149	1006	1474	1032
7	1809	1081	1780	1113	1762	1143	1741	1174	1720	1204
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	223	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2457	1711
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	16	12

	36 d.	54 d.	37 d.	53 d.	38 d.	52 d.	39 d.	51 d.	40 d.	50 d.
1	243	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	541	709	555	699	567	690	578
4	971	705	960	721	945	739	932	756	920	771
5	1213	881	1198	902	1182	923	1165	944	1149	954
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2098	1700	2069	1735
10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
1	8	6	8	6	8	6	8	6	8	6
2	16	12	16	12	16	12	16	12	16	12

	41 d.	49 d.	42 d.	48 d.	43 d.	47 d.	44 d.	46 d.	45 d.	45 d.
1	236	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	788	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1378	1550	1406	1535	1430	1511	1458	1485	1485
8	1810	1575	1783	1607	1741	1638	1727	1666	1697	1697
9	2036	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2264	1968	2229	2007	2194	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

The Structure of this Table is from this ground,

As *Radius* is in proportion to the Distance of two places measured in their Rumb, so is the Sine of the Complement of that Rumb, to the difference in latitude of these two places.

And so is the sine of that Rumb, to the distance of the Meridians of those two Places. As, admit I measure South-Easterly 20 deg. 300 Poles, here then the Rumb upon which I measure, making with the Meridian an angle of 20 degrees, I say,

As <i>Radius</i> is in proportion	
to the distance measured 300 poles	2.47712
So is the sine complement the Rumb, S. E. 20 deg.	9.97299
to the Difference of Latitude 281 $\frac{21}{100}$ fere.	2.45011

Whereby it appears, that the distance of the Parallels of these two places is 281 $\frac{21}{100}$ Poles; or that the place whereto I measure, is more Southerly than the place from which I measured, by 281 $\frac{21}{100}$ Poles. Now for the distance of their Meridians, say,

As <i>Radius</i> in proportion	
to the distance measured 300 poles,	2.47712
So is the sine of the Rumb S. E. 20 deg.	9.52405
to their distance in longitude 102 $\frac{606}{1000}$	2.01117

<i>Ch</i>	<i>Poles</i>	And thus I find the place whereto I measured is
1	28.19	more Easterly than the place from which I mea-
2	56.38	sured by 102 $\frac{6}{10}$ poles, and somewhat more. And
3	84.57	in like sort may be found all the other numbers ex-
4	112.76	pressed in this Table; but having thus found for
5	140.95	every Degree to 45 Degrees two numbers, the
6	169.14	rest may be reduced from them, as in this
7	197.33	Example: 300 poles at three poles to the Chain
8	225.52	is an hundred Chains or ten Changes, finding
9	253.71	that in ten Changes upon this Degree, the dif-
10	281.92	ference Southerly is 281 $\frac{21}{100}$ poles, it must
		for five Changes, which is just half so much,
		be



CHAP. IV.

Of the difference of Longitude, Position and Distance of York and London: And how the Maps of England may by this Experiment be reformed, especially in the Latitude of Places.



E come next to speak of the Easterly and Westerly distances gathered as before is shewed by these Tables, and to find thereby the difference of Longitude, and of this we will give an Example in the foresaid Experiment: whereby we find that the distance of Longitude, or the East and West distance between *York* and *London* is near 14000 Poles, *London* being so much more Easterly than *York*. And before we have found that in a degree of the Meridian, and consequently in a degree of the Equinoctial there is near $3709\frac{1}{10}$ Chains, at six Poles to the Chain, and this 14000 Poles converted into such Chains is $2333\frac{1}{3}$.

Which $2333\frac{1}{3}$ Chains (for finding the difference of Longitude) are not to be reckoned in the Parallel of *York*, that being too much Northerly, neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both, namely, about the Latitude of 52 degrees 45 minutes. Now to find what difference of Longitude is answerable to this $2333\frac{1}{3}$ Chains in the parallel of 52 degrees 45 minutes, say,

As Radius is in proportion	
to Sine complement the Latitude <i>sc.</i> 52 deg. 45 min.	9.78197
So is the measure of a deg. in the Equinoctial $3709\frac{1}{10}$	3.56927
to the measure of a degree in that Parallel $2245\frac{1}{10}$	3.35124
	And

And thus we find that in the Parallel, whose Latitude is 52 degrees 45 minutes, there are $2245\frac{1}{10}$ Chains answering to a Degree, whereby it appears that the difference of Longitude between *York* and *London*, is more than one degree, and to find how much more, say again by the Rule of Proportion:

As the measure of a degree $2245\frac{1}{10}$ Co. ar.	6.64876
is to a degree in <i>Seconds</i> , 3600	3.55630
So is the measure given, 2333 $\frac{1}{2}$	3.36797
to the number of <i>Seconds</i> , 3741	3.57303

Which reduced, is 1 deg. 2 min. 21 seconds, and thus we find that *London* doth differ in Longitude from *York* 1 deg. 2 min. 21 Seconds, being so much more Easterly.

Thus having the difference of Latitude, as also the difference of Longitude between these two places, we may (according to the second Problem of sailing by *Mercators Chart*) find the Rumb from *London* to *York* to be 14 degrees 20 minutes from the North to the Westwards; that is, North by West 3 degrees 5 minutes Westerly, and the distance in that Rumb 944 $\frac{1}{2}$ Chains. But their distance in the High-way, by reason of the crookedness and un-evenness of it, was more by about an eight part.

And the like may be done for the other intermediate Places between these, but affecting brevity we pass that over, as not much pertinent to our present purpose, only expressing the Latitudes of some of the principal of them, as followeth.

	Latitudes
As the Latitude of <i>York</i> ; we find to be	53 deg. 58 min.
<i>Doncaster</i>	53 deg. 32 min.
<i>Newark upon Trent</i>	53 deg. 5 min.
<i>Grantham</i>	52 deg. 54 min.
<i>Stamford</i>	52 deg. 38 min.
<i>Huntington</i>	52 deg. 19 min.
<i>Royston</i>	52 deg. 3 min.
<i>Ware</i>	51 deg. 48 min.
<i>London</i>	51 deg. 30 min.
	We

We further noted in this Experiment, that howsoever the number of miles between *Ware* and *London* are almost the same by estimation that they are by measure; yet all the way besides from *Tork* to *Ware*, a measured mile consisting of 320 Poles is but three quarters of a mile, as the miles lie by estimation or common account; so that every where (for the most part) three miles by estimation make four measured miles. And a minute or the sixtieth part of a Degree, is almost in the middle between them both: So that look how much a measured mile is less than a minute, so much or somewhat more is a mile by estimation greater than a minute; for as there is contained in a Degree of measured miles $69\frac{1}{2}$ and somewhat more, as we have before shewed, so of our common estimated miles, there are contained about 53 in a Degree.

Upon these grounds the whole Map of this Kingdom might be much rectified, especially in the Latitude of Places, for though we cannot hence determine certainly the Latitudes of any other places besides those which were in the way, or at least in sight as we came up (the principal of which we have before noted.) Yet we may nearly conjecture the Latitudes of most parts of England, by their Distances and Positions from these; but these things being besides our scope and purpose in this place, we shall only compare the latitude of some principal places, probably gathered from this Experiment, with the Latitudes of the same places, as they are set down by Mr. Speed in his Geographical Description of England; that such as please to examine both in any particulars, may know to which they may more safely lean.

	Latit. by this Exper.	Latit. by M. Sp. map.		Latit. by this Exper.	Latit. by M. Sp. map.
	D. M.	D. M.		D. M.	D. M.
Canterbury	51 17	51 29	Northampton	52 14	52 36
Chichester	50 48	50 51	Huntington	52 19	52 44
Guilford	51 12	51 22	Stamford	52 38	53 04
Winchester	51 03	51 11	Leicester	52 40	53 06
Dorchester	50 40	50 44	Lincoln	53 14	53 50
Excester	50 43	50 48	Newark upon		
Wells	51 12	51 22	Trent	53 05	53 38
Salisbury	51 04	51 12	Nottingham	53 00	53 32
Reading	51 28	51 42	Darby	52 58	53 30
London	51 30	51 45	Stafford	52 52	53 22
Colchester	51 58	52 16	Shrewsbury	52 47	53 16
Ipswich	52 08	52 30	Chester	53 16	53 52
Norwich	52 42	53 10	Lancaster	54 10	54 57
Cambridge	52 12	52 32	York	53 58	54 44
Hertford	51 49	52 06	Richmond in		
Bedford	52 08	52 30	Yorkshire	54 28	55 18
Buckingham	52 00	52 20	Kingston upon		
Royston	52 04	52 24	Hull	53 48	54 29
Oxford	51 46	52 02	Doncaster	53 32	54 12
Glooucester	51 53	52 12	Durham	54 50	55 45
Hereford	52 07	52 27	Carlisle	55 00	55 56
Worcester	52 14	52 36	Newcastle	55 03	56 01
Warwick	52 20	52 45	Barwick	55 54	57 03

The Latitudes of these Places in the first Column expressed are such as are probably gathered from this Experiment. But
in

in the second Column, there is set down the Latitudes of the same places, as they are expressed by Mr. *John Speed* in his Map of *England*, set forth in his Book, entituled *The Theatre of the Empire of Great Britain*; and least there should be any mistake in the Map, I have conferred these Latitudes thence gathered with the Latitudes of the same Places set down by him in words at large; in his descriptions of each severall County, and find them neerly to agree, except the Latitude of *Barwick*, which in his Map he makes to be 57 degrees 3 minutes, but in his Historical Descriptions of *Northumberland*; he relates it to be 55 degrees 48 minutes, which last is much neerer the truth, but seems not to be his meaning; because then he should make it more Southerly than *New-castle*, yea more Southerly than he doth *Carlisle*, which by his Map, and also by his words in his Relation of *Cumberland* is in the Latitude of 55 degrees 56 minutes. Whereas *Barwick* is above 50 miles more Northerly.

By these you may neerly conjecture the Latitudes of other parts of *England*, lying in or neer the same Parallel with any of them: And hence also it appears, that the difference of Latitude between *Barwick* and the South-coast of *England* neer *Christ-Church*, is little more than 5 degrees, not 6 degrees and more, as some of our Maps make it. But these things we must leave, that we may proceed to that which is principally intended, only we will first touch a little upon the use of the fore-going Table in Plotting and Surveying of Land.

CHAP. V.

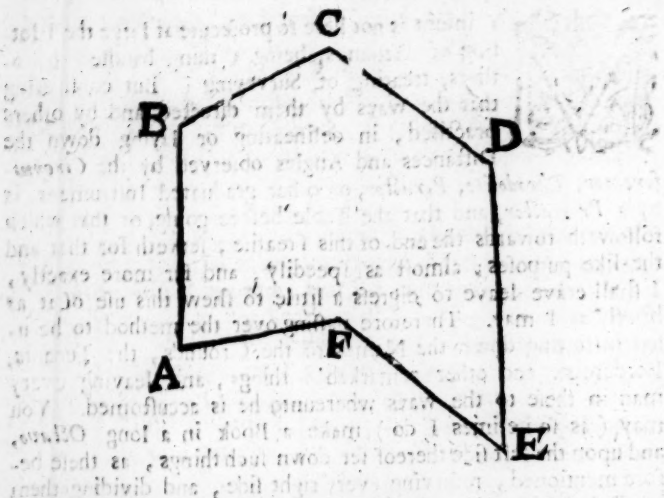
To Delineate the Plot of any Forrest, Park, Common, or other pieces of Ground, as also of Rivers, Harbours, &c. Speedily and most exactly.



MY intent is not here to prosecute at large the Plotting of Grounds, being a thing handled by others, treating of Surveying: But considering that the ways by them directed and by others practised, in delineating or laying down the Distances and Angles observed by the *Circumferentor*, *Theodolite*, *Perastor*, or other graduated Instrument, is by a *Protractor*, and that the Table before going, or that which followeth towards the end of this Treatise, serveth for that and the like purposes, almost as speedily, and far more exactly, I shall crave leave to digress a little to shew this use of it as briefly as I may. Therefore passing over the method to be used in setting down the Names of the Grounds, the Tenants, Borderers, and other remarkable things, and leaving every man in these to the ways whereunto he is accustomed. You may (as sometimes I do) make a Book in a long *Octavo*, and upon the left side thereof set down such things, as these before mentioned, reserving every right side, and dividing them by Ruled Lines into six Columns; as hereafter following appeareth.

And having taken and set down your Notes in the Field on the left sides or pages of your book, you may in the Evening or next morning before you go out, or when else your occasions will permit, set down in the first Column on the right side, how many Degrees the Lines upon which you have travelled, are distant from the North or South part of the Meridian towards the East or West; and in the second Column the quantity of the same Lines, in Changes, Chains, and single Poles, and parts of Poles.







As in this Figure, suppose the Line from A to B to be directly East seven Changes, that is, seven times 30 Poles, or 210 poles, from B to C to the Eastwards of the South 35 degrees, 8 Changes, and one Chain, from C to D, to the Westwards of the South 32 degrees, five Changes, and four Changes, from D to E,



to the Westwards of the South 80 degrees, ten Changes, from E to F, to the Eastwards of the North 35 deg. six Changes, three Chains, and two thirds of a Pole: and lastly, from F. to A, the place where I first began, to the Westwards of the North 9 deg. 5 Changes, 3 Chains, $2\frac{1}{2}$ poles: All these I express in the first and second columns on the right side, as hereafter following appeareth.

Which done, I take the Table, and find there the Northing and Southing, Easting or Westing answerable to these Degrees and Distances, and set them down accordingly. As for the first being East seven Changes, I set down in the East column 210 Poles

Poles with a Cipher behind it. For the second being *S E*, 35 deg. I find in the Table for 5 Chains 1228¹⁰ to be set in the South Column; and 860 for the East Column; also upon the same degree for 1 Chain 25 for the South Column, and 17 for the East Column; and so I proceeded with all the rest, untill I have finished.

Deg.	Dist.	North.	South.	East.	West.
East.				2100	
<i>S E</i> 35			1228	0860	
<i>S W</i> 32			0025	0017	
<i>S W</i> 80			1272		0795
			0102		0064
			0521		2954
<i>N E</i> 35		1474		1032	
		0074		0052	
		0005		0004	
<i>N W</i> 09		1481			0234
		0089			0014
		0025			0004
		3148	3148	4065	4065

And being thus returned to my first Station, I summe up severally these four Columns of North, South, East and West; and finding that the summe of the North column is equal to that of the South, and the sum of the East is equal to that of the West, I conclude the whole Work to be truly performed, whereas if there had been any difference, it had shewed an Error; and if that difference had been great, it had been necessary to examine the Work again, and so to correct it.

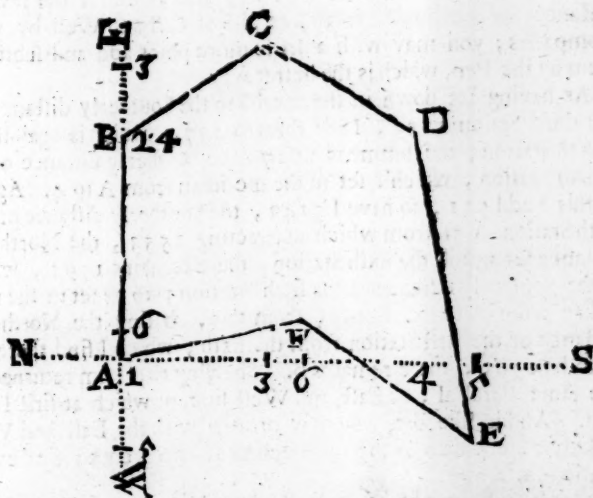
It is usual to add together all the angles, and also to multiply to right angles, or 180 degrees by the number of angles lacking two, and if the sum of the angles added together be equal to this Product, the work is thought to be true: as here, if we add the inclinations and reclinations of these Lines in this Figure, the sum is 720 deg. or eight right angles, and if we multiply two right angles by 4, (because here are six angles) the Product is also eight right angles. But the other by the summes of the Columns, is a most absolute way for examining the truth of your work, and to be preferred before any other that I know.

It may seem very laborious to set down every Station in this manner, but one that is a little exercised in it may, as I take it (for I never observed the time exactly) set down 40 or 50 Stations in this manner, withithin the space of an hour, or thereabouts; but I should advise that it be done by two men, having each a Table for that purpose to avoid all mistakings.

If your Instrument give not the angle with the meridian expressly, yet it may easily be gathered thence, or else you may divide a Circle as your Instrument is divided, and number the Degrees as they are numbred; which done, number them also from the North and South part of the Meridian towards the East and West, so shall you easily know the angle of any Degree with the Meridian.

Now to proceed, these measures may be set down in a Plot several ways. As first, considering which way the ground lies, I take a point for my first Station, so as the whole may fall conveniently within the plot, which let be the point A, by which point I draw a meridian and parallel, namely two right lines intersecting one another at right angles; whereof let *NS* be the meridian running North and South, and *EW* the parallel running East and West; this done, I look to the North and South Columns, and there first in the South Column, and against the third Station, I find 1253, that is, $125\frac{3}{4}$ Poles, this I set in the meridian from A, to the Southwards, and mark the point with the figure 3, then in the South Column against the fourth Station,

Station, I find 1374, which I set in the Meridian from 3 to 4: also against the first Station I find 521, which I set in the Meridian from 4 to 5: then against the Sixth Station, I find in the North column 1553, which I set in the meridian from 5 to 6: also against the seventh Station, which is the same with the first, I find 1595, which I set in the meridian from 6, and it falls upon A, which is the first Station: and thus I have done with the South and North columns.



In like sort I express the measures in the East and West Columns in the Parallel E W. As finding first in the East column 2100, I set it down from A to the Eastwards, and it extends to B, where I set 2, signifying my second Station; I find next in the East Column 877, which I set in that Parallel from 2 to 3, next in the West Column 859, which I set in that Parallel from 3 to 4: and so I proceed with the rest. And having thus set down the measures in the meridian and parallel, we have also as it falls out in this Example two Stations express'd, namely A and B,

now

now for the third; I take in the Parallel with my Compass the distance A 3, and setting one foot in the meridian at 3, I strike an arch neer C; also taking in the meridian the distance A 3 and fixing one foot in the parallel at 3, I cross the aforesaid arch neer C; the intersection of these two arches is the point C, representing the third Station.

In like sort, I proceed to find the points D E F for the fourth fifth, and sixth Stations, then drawing Lines, namely from the first Station A to the second B, and from the second to the third C, &c. We shall describe the Figure required A B C D E F.

Otherwise, whereas here you add and substract the several distances of South and North, as also of East and West by your Compasses; you may with a little more pains add and substract them by the Pen, which is the better way.

As having set down in the meridian the Southerly distance of the third Station 1253, I add thereto 1374, which is against the fourth Station, the summe is 2627; the Southerly distance of the fourth Station, which I set in the meridian from A to 4. Again, to this I add 521, so have I 3148, the Southerly distance of the fifth Station A 5, from which substracting 1553, the Northerly distance set against the sixth Station, there remains 1595, which is the Southerly distance of the sixth Station, to be set in the meridian from A to six. Lastly, from this, abating the Northerly distance of the first Station from the sixth, which I find there also to be 1595, there remains 0. Shewing that I am returned to the same Parallel, or East and West line, in which at first I began. And in like sort, you may proceed with the East and West columns, and then by the intersection of two arches, find every Station, as before.

Other ways might be prescribed, which will not be hard to find of your self. And as we may thus lay down any irregular right-lined Figure far more exactly than by the *Protractor*: So when it is laid down after this manner, we may cast up the *Area* or Superficial quantity of it very exquisitely: Yea, if there should be a Plot drawn (according to the Angles and Distances here given) after the usual manner by a scale and divider, the Area might be found by the Scale

Scale so large, that the Plot should be an hundred times so great as this; yet could not the content thereof be cast up so exactly and certainly as it may be here.

But I must not insist upon these things, they may of themselves be conceived, and mine intent is only to touch them, that I be not prevented of time, and by other occasions from handling those things which I have here more specially intended.

But as I have said, this course is chiefly to be used in plotting large grounds, and there indeed are graduated Instruments, especially to be used: for other smaller grounds, there is none more fit than the *Plain Table*.

CHAP. VI.

Of the Compass of the Earth, and the quantity of a Degree, according to the most approved Experiments Ancient and Modern.



Although the Compass of the Earth hath been in some sort observed by divers of the Ancients: Yet for some of them we cannot certainly gather what measures they used; others used no measure at all, but assumed the Distance of Places to be such as it was estimated by Travellers to be, and likewise the Latitude; therefore it will be needless to insist upon the examination of their observations, others of them which were taken by measure, and which we may upon any good Ground reduce to our measures, are these which follow.

Willebrordus Snellius in his Book entituled *Erastosthenes Batavius*, cites *Abel Fedas*, a most diligent *Arabian* Geographer, that lived about the year of Christ 1322, who records, that
about

about the year of Christ 827, certain men skilfull in the *Mathematicks*, did by the commandment of their Prince *Amanon*, measure in the fields of *Mesopotamia* (as he gathers) under one and the same Meridian, from the North towards the South, the quantity of a degree, and found it to be 56 miles or somewhat more. The quantity of their mile, according to *Alphraganus*, was 4000 Cubits, or 6000 Feet, whence the quantity of a degree should be 336000 Feet, but of the length of their Feet we are something uncertain, only they define it to be so long as the extent of 96 barley corns laid side by side; whereas the *Rhyndland*-foot, according to tryal by him made, is but the extent of 90 corns laid in like manner, so that if there be no inequality in the grains, then 90 *Arabian*-feet are equal to 96 *Rhyndland*-feet. But 96 *Rhyndland*-feet are found to be about 91 $\frac{1}{2}$ *English*-feet, therefore also, by the Rule of Proportion, 336000 *Arabian*-feet do make of our *English*-feet 370222. So that according to this Experiment of the *Arabians*, a Degree should contain 370222 of our *English*-feet. And before we have found by the Observations taken at *London* and *York*, and by the distance of their parallels measured, that a Degree contains of our *English*-feet 367200. The difference is only 3022 feet, that is about the $\frac{1}{12}$ part of a degree or half a minute.

He cites next *Alhazen* the *Arabian*, who in his Book *de Crescensculis*, declares the compass of the Earth to be 24000000 Paces, so that proportionally there must be in one degree 66666 $\frac{2}{3}$ paces, that is 333333 *Arabian*-feet. And seeing that 90 *Arabian* feet make of our *English*-feet 99 $\frac{1}{2}$, therefore by the Rule of Proportion 333333 *Arabian*-feet, make of our *English*-feet 367283: So that according to *Alhazen*, there should be in a Degree 367283 of our *English*-feet differing from the Experiment which I made only 83 feet in a Degree.

I have not strained these numbers to bring them to this necessity, they are the same in effect which are set down by *Strabon* in his *Eratostrones Berytus*, who with great industry and judgment hath compared the measures of the Ancients, and the measures used by several Nations in these times, with the

Rhynd-

Rhyndland-foot. Much less have I strained mine own numbers to draw them up to these: But on the Contrary, I confess upon the sight of his Book, observing the great pains and industry which he professeth himself to have bestowed, and which I doubt not but he did imploy in making his Experiment, and how he had found the measure of a Degree to be much less than mine, as we shall after shew, I began to doubt that I had not made sufficient allowance for the un-evenness of the ways, and for some small bendings, sometimes to the right hand, sometimes to the left, the observation whereof I wittingly neglected, to spare time and Expence. For I did often observe a mile or two before me, some Mark in the High-way noting the degree, and measuring to it in the way, neglecting to observe the intermediate swervings of the way, sometimes three or four degrees towards the right hand, sometimes as much to the left, but making such allowance for that, and for the un-evenness as I judged sufficient. And some men may think, that the exact Observation of these lesser things thus neglected and regulated only by judgment or conjecture might deceive me much: But they may consider, that if there be two places a mile distant, that is, in a right line 320 Poles, if you measure from one of these places towards the other, not in that right line, but always swerving from it by an angle of 4 degrees, sometimes to the right hand, sometimes to the left, till you come to that other place; I say, that notwithstanding all these swervings (if there be nothing else to augment the measure) it will not amount to 321. Now considering that I had all the way, as occasion required, made such allowance as seemed convenient, and so found 367200 Feet in a degree, before I compared it with the measures taken by any other: I resolved not to diminish nor to augment the number thus arising by my Observations, Measures, and Allowances, in respect of the Opinions, Observations, or Measures of any other man, untill there be made some Experiment more evident and exact than any yet extant. And I am something the more confirmed by the neer agreement of these two testimonies before recited, both exceeding me a little in the measure of a degree. But we cannot con-

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fidently rest upon them, because of that inequality which may be of Corns or Grains; for theirs may haply be something greater or lesser than ours.

Both these measures of a Degree do much exceed the quantity of a Degree found by *Snellius*, but when he compares them with his own another way, namely, placing the Barley-corns so that they may not lie flat, but be set up edge-wise, and so by 96 Corns to make a Foot, and by such Feet to measure a Degree; then he finds that the quantity of a Degree, according to the *Arabians*, is much less than by his Experiment it should be: but if some be laid flat, and others set up edge-wise, the *Arabian* measure of a degree will agree with his. And so he proposeth this doubt, whether the 96 grains whereof the *Arabian* foot doth consist, must lie flat or be set up edge-wise, or some of them to lie flat, and others to be set up edge-wise. But it is most probable that they must lie flat, that being the position which they are apt unto by nature; they cannot be set edge-wise without much trouble, especially so many together as make the length of a foot, and so the *Arabian* measure of a degree doth nearly agree to this of mine.

We come next to hear the determination of *Ptolomy* of *Alexandria*, whose authority and credit in the solution of this question is not inferior to any of the Ancients. He affirms the Compass of the Earth to be 180000 *Stadiums*, and the quantity of a degree 500 *Stadiums*; the same (as *Strabo* saith in his 2 Book of *Geography*) was before affirmed by *Posidonius*. Also *Marinus Tyrinus* (before *Ptolomy*) had determined the quantity of a Degree to be 500 *Stadiums*. *Ptolomy* confirms it, not simply from their relations, but as it seems from his own experience, and that by some measures diligently taken, for the 11 Chapter of the first Book of his *Geography*, he hath these words; *Sed in hoc quoque recte sentit, partem unam qualium est circulus maximus trigentorum sexaginta; quingenta in terra consistere Stadia, id enim confessis dimensionibus consonum existit. Also lib. 7. cap. 5. Ita ut pars una, seu gradus unus quingenta continent Stadia, quemadmodum ex diligentibus deprehensum*

sum est dimensionibus. Now a *Stadium* not only amongst the *Greeks*, but as appears by *Herodotus* amongst all other Nations of *Asia* and in *Egypt*, did consist of 600 feet: therefore a Degree according to *Ptolomy*, must contain 300000 feet. But the *Egyptian* or *Alexandrian*-foot was much greater than our foot; for as we have before said, the ancient *Roman* foot is greater than ours, and the *Egyptian*-foot was much greater than the *Roman*: For it is often testified by *Hero Mechanicus*, that five *Alexandrian*-feet make six *Roman* feet. And Mr. *Snellius* hath very ingeniously gathered both from *Philandes* and otherwise, that the *Rhymland*-foot is equal to the ancient *Roman*-foot; therefore also five *Alexandrian*-feet are equal to six *Rhymland*-feet: So that by the rule of proportion, 300000 *Alexandrian*-feet will make of *Rhymland*-feet 360000. But by the size of our *English*-foot, which was sent him from the Iron-Standard in *Guild-hall*, he finds it to contain but 968 such parts as the *Rhymland* contains 1000: So that 968 *Rhymland*-feet are equal to 1000 *English*, or 121 *Rhymland*-feet are equal to 125 *English*-feet. Therefore also by the Rule of proportion, 360000 *Rhymland*-feet are equal to 371900 of our *English*-feet. Therefore according to *Ptolomy*, there are contained in a Degree 371900 of our *English* feet. But by our fore-mentioned Experiment made between *York* and *London*, we find only 367200 feet in a Degree, being less than *Ptolomies* by 4700 feet, that is, by $\frac{1}{20}$ part of a Degree, or $\frac{1}{2}$ of a Minute, and little more.

Fernelius a modern Author and learned Physician, measuring the way by the Revolutions of a Wheel, and the Latitudes by Observation, finds in a Degree 68 *Italian* miles, and 96 paces, the Pace which he used being more than five of our *English*-feet: But because he handled not the Problem exactly, and is suspected by *Snellius*, (though I think without cause) to have grounded his Conclusion rather upon the Experiment of the *Arabians* before set down (wherewith it doth nearly agree) then upon his own, we will insist no longer upon it.

We come in the last place to the Experiment of *Willebrordus Snellius*, a *Hollander*, made in the *Netherlands* about 20 years

past. We shall not need to recite the particulars of it, being extant at large in his Book before mentioned, but in Conclusion he finds in a Degree 342000 *Rhyland*-feet. Now a *Rhyland*-foot (as he hath there shewed, comparing both together) is greater than ours, and that in such proportion, as 1000 is to 968, (and so much or little more it appears to be by that Model of the *Rhyland*-foot printed in his Book) therefore 968 *Rhyland*-feet must make 1000 of ours; and hence by the Rule of Proportion, 342000 *Rhyland* feet, will make of our *English*-feet 353306. So that there should be in a Degree only 353306 feet, which is less than we have before found in a Degree, by 13804 feet, that is, by $\frac{1}{12}$ part of a Degree, or $2\frac{1}{2}$ Minutes, and something more. He was a man doubtless of singular industry and knowledge, and of so much exercise in the Mathematicks, and it may be, as well experienc'd in this particular, touching the Geometrical mensuration of distances, and he hath bestowed much pains and diligence in this Experiment, as by his Book appeareth. But if he had by a Chain measured the Distance of his two utmost Stations (if the ground would permit, which I suppose it would not) or at least-wise if his measured Stations had been further distant: I conceive he would have found a greater Distance in his two utmost places of Observation. But if a man, intending to find the Distance of two places, measure only the $\frac{1}{100}$ part of that Distance, and by that measured Line and the angles, think to find their true Distance; whether he do it immediately from those two measured Stations, or mediately by help of others observed from them, he may easily fall into some notable Error. For though the Problem be exactly true in Geometrical Demonstrations, how small soever the measure be, yet it is not so in sensible and experimental practises, by reason of the weakness even of the best eye, and the imperfection of the Instruments in themselves, and in their use. And besides that, there were many Stations obliquely situate; A man cannot always hit the just middle of that Turret, Steeple, or other mark which he observes: Neither when he comes to make his Station there, can he always place his Instrument just at the concurrence of his former

mer visual Lines; by reason of other impediments. Besides the force of the wind in such eminent places: add moreover that amongst so many Steeples as there are in some Towns, there, a man may at some time mistake one for another. And if there should happen no notable Error, by reason of any or of all these Casualties: Yet may two Minutes in the difference of the Latitude of two places be easily mistaken, especially being derived from the Latitudes of those places which are very rarely set down true to a minute.

If it be objected, that I might aswell be so much mistaken in the difference of the Latitudes of *York* and *London*.

I answer, it is not so likely, because I had the opportunity of observing the Summer Solstitial Altitude of the Sun in both places, wherein I had no necessary use of the Sun's Parallax nor Refraction, nor of the Table of the Sun's Declination, any of which may cause more than a minutes error, in finding the Latitude of either place.

Besides, if mine Error in those Observations should be full as much, yet would it not in the Conclusion be half so much, because the difference in Latitude of the two places of mine Observation is more than twice so much than that of his.

But let this suffice, leaving every man to embrace that which he shall best approve. Both our experiments do sufficiently convince that common error of counting only 300000 *English* feet to a Degree, besides the consent of other Observations before recited ancient and modern.

Mr. *Snellius* hath further in that Book of his, entituled *Eratosthenes Batavius*, with much diligence compared some ancient measure, as also the measures of sundry Forreign Countreys with the *Rhymland*-foot; and amongst the rest our *English*-foot, according to a size thereof to him sent from the *Standard* in *Guild-Hall*, (from whence also I had about twenty years past the size of that Foot which I have used in this measure) we shall not need to repeat them all, because his Book is extant: some of them are these following, which we here compared to our *English*-foot, as he hath there done to the *Rhymland*, that so any of them

them may the more easily be reduced into our Feet. Therefore dividing the *English-foot* into a 10000 equal parts, we shew how many of those parts are contained in other ancient and forreign feet.

Ancient feet compared with our *English-foot*.

Of such parts as the *English-foot* contains 10000

Ancient *Roman-foot* contains 1033

Ancient *Greek-foot* contains 1076

The *Babylonian* contains 1111

Alexandrian contains 1240

Antiochian contains 1405

Arabian contains 1102

Forreign feet compared with our *English-foot*.

Of such parts as the *English-foot* contains 10000

Rhyndland-foot contains 1033

Dort-foot contains 1083

Middleburge-foot contains 992

Amsterdam-foot contains 934

Antwerp-foot contains 939

The *Levain-foot* contains 939

Hafnium-foot in *Denmark* contains 965

Paris-foot called the *Kings-foot* contains 1090

Venice-foot contains 1157

Toledo-foot contains 896

Nureberg-foot contains 1066

Stratsburg-foot contains 930

CHAP. VII.

Of dividing the *Log-line*, and reckoning the ships way.

THERE be four things, upon which the Practice of Navigation is especially grounded; namely, the knowledge of the Longitude, Latitude, Course, and Distance. Touching the Longitude, though it may be found by the other three, yet hitherto there hath not been delivered any general Rule true practiceable, whereby the Longitudes

itudes of places might be immediately and ordinarily found of themselves. The Latitudes of places may immediately be found by Observation of the Sun and Stars, as we have formerly shewed in the Appendix to the Doctrine of Triangles: The Course by the Compass, the Variation being duly observ'd, wherein we have many good Mariners very expert, this we have also handled in the Doctrine of Spherical Triangles. The distance run is found of it self by the *Log-line*, whereof we are here to speak.

The ground of finding the distance run by the *Log-line* is meerly conjectural, being founded upon this opinion, that five of our feet make a pace, and a thousand such paces make a mile, and that 60 such miles make a degree; so that a degree should contain 300000 of our feet: But it appears not only by this Experiment, but even by all others that were diligently taken, and their measures to us known, that there is a greater number of our feet contained in a degree.

There be three things (as I conceive) that have caused this error to be so commonly received and tolerated. The one, for that it doth somewhat counterpoize another contrary error in the Practice of *Navigation*, namely in the use of the *Plain Chart*; for the error which is there committed by making every parallel equal to the Equinoctial, and so every degree in them greater than they should be, is something moderated by this error, whereby the measure of a degree is esteemed less than indeed it is.

For instance; It is evident by the *Globe*, that the Meridians concurring in the Poles grow neerer and neerer together, as they grow towards the Poles: Insomuch, as if two Meridians be distant in the Equinoctial ten degrees, that is, 600 miles, the same Meridians in the Latitude of 35 degr. will be distant little more than 490 miles. Now if unto every mile we account according to the former experiment 6120 feet, then is the distance of those two Meridians in that Parallel neer 3000000 feet. In like sort in the *Plain Chart* ten degrees of that Parallel (as of all others) is made equal to ten degrees of the Equinoctial or Meridian:

so that the distance of these two Meridians will upon the *Plain Chart* be 600 miles, but one of these miles contains only 50000 feet, so that the distance is but 3000000 feet, equal to the former.

And although these errors in other cases do not justly ballance one another as in this example, yet that of the *Plain Chart* is always something moderated by this other, and so much the more by how much they are neerer to the foresaid Latitude. I grant that this is only so, when the course is neer unto the East or West points; but withall, I say that this kind of reckoning is (in a manner) then only used: For he that runs any course neer the Meridian Southerly or Northerly, hath a more certain way of reckoning; namely, his Latitude, which he finds daily by Observation of the Sun and Stars, upon which we will depend, either neglecting or least not regarding his dead reckoning. Yea, (it may be) never casting the *Log* so much as once in such a Voyage, having a more sure ground for his reckoning. But in a Course that is neer East and West (forasmuch as there is no way discovered for finding the Longitude) he is driven of necessity to make use of his dead reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of those which consist of Courses much Easterly and Westerly, as to and from the *West-Indies*, and the Parallel of *Cape bon Esperance* are neer unto this Latitude of 35 degrees so that as some of them are more Southerly, others of them are more Northerly.

But to insist no longer upon this, I suppose a second cause to be, for that men commonly desire to have their reckoning before their Ship (as they say) that they fall not with a place before they look for it; and this comes so to pass, whilst the miles are accounted less in measure, and so more in number than they are indeed.

And thus, though there may seem to be some commodity in these errors, especially when they do neerly ballance one another: Yet because they seldom do so, but always leave men in uncertainties, and often times in great perplexity and danger,

it

it is much safer and better to reject them both, and to imbrace those wayes, which are evidently grounded upon truth, though there may be in them some more difficulty at the first. Yet I confess, that he which reforms one and not another, may sometimes erre so much the more thereby. And I doubt not, but many would reform them both, if they could certainly do so.

Therefore a third cause of admitting and retaining this Error seems to be, for that there hath been no way delivered from evident and certain grounds, for the rectifying of it. I doubt not but many have found Errors in their reckonings arising from hence, that they account only 300000 of our feet to a Degree; but not knowing certainly where to lay the fault, have imputed it sometimes to ill steerage, otherwhile to the Variation of the Needle, or to some mistake in their Reckonings, or to some error in their Plots, or to some Current, or such other accident, and so the Error hath rested un-reformed. Wherefore although the practical performance of this Problem for finding the Circumference of the Earth, or the quantity of a Degree on the same, have many singular uses which I cannot now touch; yet that which amongst the rest I chiefly aimed at, was that we might have a more sure and evident ground for dividing the *Log-line*, and for reckoning the ships way or distance run more truly upon any Rumb or point of the Compass than formerly.

And now to apply it to this purpose, we have noted before (*Chap. 2.*) that by the Experiment there expressed, we find in a Degree on the circumference of Earth and Sea, 367200 of our *English*-feet. Wherefore retaining still the same division of a Degree into 60 miles or 20 leagues (as hath been formerly used) a Mile will contain 6120 feet, or 1020 fathoms; And so a League contains 18360 feet, or 3060 fathoms; for dividing 367200 by 60, the quotient is 6120. &c. Thus then 60 miles being a Degree, every mile is 6120 feet.

Now supposing the time of the running out of the *Log-line*, to be measured by an half-minute glass, if we observe how many feet or fathom she runs in half a minute; we may thereby find her way for an hour or four hours, or for any other time proposed.

As admit there runs out of the *Log-line* in half a minutes space 51 Feet, or $8\frac{1}{2}$ Fathoms, and you would know what way the ship makes every hour after the same rate;

Say by the Rule of Proportion;

If $0\frac{1}{2}$ Minute, give 51 Feet,

What gives 60 Minutes? Or,

If 1 Minute give 102 Feet:

What gives 60 Minutes?

And so multiplying, you shall find 6120 Feet, which is one mile. Or, if you would find her way for four hours, which is 240 minutes; Say,

As 1 minute, is in proportion to 240 minutes,

So are 102 Feet, to 24480 feet, or 4 miles.

Or if you would have it in fathoms; say,

As 1 minute is in proportion to 240 minutes,

So is 17 fathoms, to 4080 fathoms, the ships way in four hours. The like is to be conceived, if your Glass be for any other quantity of time above or under half a minute.

Some have thought that the way which the ship maketh, may be known to an old Sea-man by experience (as they say) that is, by conjecture: Which opinion makes some neglect the use of the *Log*, lest they should be accounted young Sea-men. But as he that rides often will have some neer guess how far the Pace he rides will carry him in an hour (because he hath often observed it formerly) so he which hath often sailed and kept an account of the ships way by the *Log*, will be able to give some neer estimate of her way without the *Log*. But it is incident to some men to have such a conceit of this their estimate, that they think it more certain than the Rule it self, from whence it is derived, especially if it chance to answer their expectations at some times.

It is thought also that the ships way may be known by two marks on the ships side, but this is doubtless very uncertain, both by reason of the shortness of the time, and in respect of the dead water (as they call it) by the ships side. For the water which is neer the ship, is drawn along with the ship in her motion,

motion, and so much the more, by how much the neerer.

But if any desire to make tryal of this way, it is to be considered; that 17 foot is $\frac{1}{160}$ part of a mile, and 10 sec. of a minute is $\frac{1}{6}$ part of an hour; therefore if there be two marks on the ships side distant 17 feet, if the ship run the distance of these two marks in 10 seconds, she runs a mile an hour, if in 5 seconds two miles an hour, if she runs that distance in 2 seconds, she runs 5 miles an hour. And so always dividing 10 seconds by the number of seconds, in which the ship runs that distance, the quotient shews the miles and parts of a mile run in an hour.

But if the Distance of those two marks be 34 feet, if she run it in 20 seconds, it is after a mile an hour, if in 10 seconds, two miles an hour, if in 5 seconds four miles an hour: And so always dividing 20 sec. by the number of sec. in which the ship runs that distance, the quotient shews how many miles the ship runs in an hour. As if the ship run that distance of 34 feet in 8 seconds, then dividing 20 by 8, the quotient is $2\frac{1}{2}$, shewing that she runs $2\frac{1}{2}$ miles in an hour. Or, if you can conveniently make the distance of the two marks on the ships side to be 51 feet (for the further they are distant, the better) then if the ship run that distance in 30 sec. it is a mile an hour, if in 10 sec. it is 3 miles an hour, and so always dividing 30 sec. by the number of seconds, in which the ship is running that distance, the quotient shews after that rate how many miles the ship runs in an hour.

Otherwise you may do thus, divide 17 feet in 10 parts, and set as many of those parts on the ships side, as conveniently you may, (which according to the ships length will be more or fewer.) Then when the ship runs one of those parts in a second of time, it is a mile an hour: when two, it is two miles an hour; when 5, it is 5 miles an hour. And in general, if you divide the number of parts run by the time of running accounted in seconds, the quotient shews what number of miles after that rate are run in an hour.

As if she run 30 of those parts in 5 seconds, it is 6 miles an hour; for dividing thirty by five, the quotient is six; so if she runne 42 of those parts in ten seconds, dividing 42

by 10, the quotient is $4\frac{2}{10}$, which sheweth the ships way at that time to be after the rate of four miles and two tenths of a mile in an hour.

But for keeping this account of time it may be done either by a Sand-glass for that purpose, or by pronouncing certain words or numbers: as the time wherein a man tells twice 60, pronouncing every number as fast as he can conveniently and distinctly, is about a minute, so that the time wherein a man is numbring 60, is a half minute or 30-seconds, and whilst a man is numbring two (as one and twenty, two and twenty) is a second, and so whilst a man is numbring from twenty to thirty, is five seconds, from twenty to forty ten seconds, &c. but in numbring from one to twenty you may observe the same times, as in numbring from one and twenty to forty, and this will not be hard to do; for whilst a man pronounceth one and twenty, two and twenty, three and twenty, &c. there remains a certain Impression in the fantasie, whereby a man is able in the same times to pronounce one, two, three, &c. And although this rule of numbring twice 60 for a minutes space be not general unto all men, because some are swifter or slower in their pronounciation than others; yet after this Example, a man making tryal may frame a Rule to himself, whereby he may come something near the truth.

But leaving these, we come to the division of the *Log-line*, according to the half-minute-glass, which is more usual and certain. And considering that half a minute is of an hour the $\frac{1}{120}$ part, therefore the ships way running 51 feet in half a minute is a mile an hour, if she run twice so much, that is, 102 feet in half a minute, it is two miles an hour; if thrice so much, it is three miles an hour. And in general, how many times 51 feet she runs in half a minute, so many miles is her way for an hour. Therefore leaving half a score fathom, or more from the *Log*, that so it may be out of the *Eddy* of the ships wake, before you begin to account or turn the glass, if there you make a mark for the beginning, and so 51 feet from thence a mark of one knot, and 51 feet further a mark of two knots, and 51 feet further (that is, 153 feet from your first mark) another mark of three knots, and

and so proceeding: look how many knots are veered out in half a minute, so many miles is the ships way for an hour. Now for that which is veered out more above the just measure of a knot or knots, you may allow for every five feet the tenth part of a mile almost. As admit she run 5 knots, and 25 feet in half a minute, then is her way according to $5\frac{1}{10}$ or five miles and an half in an hour, if six knots and ten feet, it is $6\frac{2}{3}$ miles in an hour, &c.

But according to the common opinion of 5000 feet to a mile, and 60 such miles to a Degree, there should be something less than 7 fathom, namely, $41\frac{2}{3}$ feet to a knot.

And although he which veers the *Log-line* be carefull to overhale it so slack, that it may not draw forwards the *Log*, yet (no doubt it doth lose some way, following the ship a little as it is drawn by the Line, and withall by the *Eddy* of the ships wake, and sometimes also is cast forwards by the wind and waves, when they come after the ship; so that for these causes it is like there may sometimes be allowed three or four fathoms more than is veered out, but this, (as a thing mutable and uncertain) being sometimes more, sometimes less, cannot be brought to any certain Rule, but such allowance may be made for it as a man in his experience and discretion finds fit.

If you would divide the *Log-line* so as it might give the ships way in *Centesmes*, or the hundredth part of a Degree, and fit it to a half-minute-glass. Then seeing the hundredth part of a Degree is 3672 feet, and the $\frac{1}{10}$ part thereof is 367.2 feet; If you begin at the mark at which you mean to turn the glass, and measure from thence 30 feet, and three fift parts of a foot, you may there place one knot, and thence again measuring 30 feet, and 3 fifth parts of a foot there place two knots; and so proceeding at the end of every 30 feet and three fifths, adding a knot, the number of knots which run out in half a minute, is the number of *Centesmes* which the ship runs in an hour. As suppose there run out ten knots in half a minute, then the ships way is according to ten *Centesmes* of a Degree in an hour, that is, the tenth part of a Degree, or six miles. And so every three foot above the
just

just measure of knots, is neer the tenth part of a *Centesimal*, or the 1000th. part of a Degree. As if there run out of the *Log-line* 5 knots and 12 feet, then the ships way for an hour 5 *Centesmes*, and 4 tenth parts of a *Centesimal*: the like is to be understood of others.

And after the form of these examples you may divide the *Log-line* for any other quantity of Time, more or less than half a Minute, or for any other parts of a Degree proposed.

Thus have we handled the division of the *Log-line*, according to the measure before found of 367200 *English*-feet in a Degree: But because (as I have before-shewed) the ships way is commonly more than by the *Log-line* it appears to be: and every man desires to have his reckoning something before his ship, that he fall not with a place unexpected, for these and such other causes, and for the rotundity of the number, if any man think it more safe and convenient in Sea-reckonings, he may abate 1 in 51, and so assign to a Degree only 360000 feet, and consequently to a mile 6000 *English*-feet.

And upon this ground, if in half a Minute there run out 50 feet of the *Log-line*, it is a mile an hour; and so if 100 feet run out in a minute.

For, as 1 minute is in proportion to 60 minutes:

So is 100 feet, to 60000 feet.

And so forasmuch as twenty five feet is $\frac{1}{240}$ part of a mile, and 15 seconds is also $\frac{1}{240}$ part of an hour: Therefore if there be two marks on the ships side distant 25 feet, if the ship run the distance of these two marks in 15 seconds, it is after the rate of a mile an hour; if in 5 seconds, it is three miles an hour; and so always dividing 15 seconds by the number of seconds in which the ship runs that distance, the quotient shews the miles and parts of a mile run in an hour. But if the Distance of these two marks be 50 foot, then if she run it in 30 seconds, or half a minute, it is mile an hour; if in 10 seconds, three miles an hour; if in five seconds six miles an hour, (for 30 divided by 5, the quotient is 6.) And so always dividing 30 seconds by the number of seconds, in which the ships runnes that Distance

stance; the quotient shews how many miles she runs in an hour, &c.

Otherwise, if you make a mark on the ships side at every twenty Inches, then when the ship runs one of these parts in a second of time, it is a mile an hour: when 5, it is 5 miles an hour: if she run 18 of these parts in 3 seconds, it is 6 miles an hour. For dividing 18 by 3, the quotient is 6. And in general, if you divide the number of the parts run, by the number of seconds spent in running, the quotient shews the ships way in miles for an hour.

But for dividing the *Log-line* according to this ground of 6000 feet in a mile, if you intend to use it with a half Minute-glass; then because half a Minute is $\frac{1}{120}$ part of an hour, and 50 feet is also the $\frac{1}{120}$ part of a mile: Therefore when the ship runs 50 feet in half a Minute, her way is after the rate of a mile an hour; if 100 feet in half a Minute, it is two miles an hour, &c.

Therefore half a score fathoms or more from the *Log*, you may make a mark, and beginning from thence measure 50 feet, and there make the first knot, and 50 foot farther two knots, and 50 foot farther three knots, and so proceeding: Look how many knots is run out in half a Minute, so many miles is the ships way for an hour. And every five feet more besides the knots in a tenth part of a mile; As if there run out six knots and 20 feet in half a Minute, the ships way is after the rate of $6\frac{2}{5}$ miles in an hour, &c.

And so if the Glass were for any other time more or less than half a Minute, you may make the distance of your knots proportional: As if it were for 20 seconds, then because 20 seconds is of an hour the $\frac{1}{180}$ part, I divide a mile, which is 6000 feet, by 180, and the quotient is $33\frac{1}{3}$; therefore there must be a knot at every 33 feet and 4 inches.

If your Glass be 36 seconds, which is $\frac{1}{100}$ part of an hour, divide 6000 by 100, the quotient is 60, shewing that there must be 60 feet to every knot, and then every six foot over and above the knots, is a tenth part of a mile more,

And

And so it is better that your Glafs be more than half a minute rather than lefs, and the more the better, provided that there run out no more Line then you may hale in again, without danger of breaking.

Lastly, if you would so divide the *Log-line*, that it might shew the ships way in *Centesmes* of a Degree, and fit it to an half-minute-glass: Then forasmuch as the hundredth part of a Degree is 3600 feet, and the $\frac{1}{360}$ part thereof is 30 feet, therefore beginning at the mark whereat you intend to turn the Glafs, measure from thence 30 feet, and there make one knot, and at thirty feet further two knots, &c. Then look how many knots run out in half a minute, so many *Centesmes* of a Degree is the ships way for an hour. And so if the glass be 36 seconds, then every knot must have 36 feet, &c.

Now if a man sailing between two Places, which lie neer East and West one from another, have kept his reckoning by Course and Distance, using a *Log line* so divided, that it have a knot at every 7 Fathoms (as many do) and would reduce the Distance of those two places so found, to their Distance in such miles, as these of sixty to a Degree, each containing (as we have said 6000 feet: The proportion in number of those to these, is as 6 to 5: for 6 of them make 5 of these.

As admit a man in his dead Reckoning, using such a *Log-line* as hath a knot at every 7 Fathoms, and for every knot running out in half a minute, he accounts the ships way to be so many miles an hour; and according to such a reckoning suppose he find the distance of two places to be 1224 Miles, or 408 leagues, and would know the Distance of the same places in miles of 6000 feet to a mile, which is according to a *Log-line* that hath a knot in every 50 feet.

Say then by the Rule of Proportion;

As the number 6	<i>Co. ar.</i>	9.22185
Is in proportion to 5,		0.59897
So is the number of miles given 1224		<u>3.08778</u>
To the number of miles required, 1020		3.00860

Which

Which 1020 is the distance of those two Places, in such miles whereof 60 make a Degree; Or to find the same in leagues, the proportion is; As 6 to 5; so is 408 leagues, to 340 leagues.

And thus may the Distances of places be found in such miles, whereof 60 make a Degree, especially if with the distance expressed in the *Plain Chart*, you compare the reckonings of some skilfull Mariners that have sailed from the one to the other. But thus to endeavour a reformation of the *Plain Chart* were a labour to little purpose; For there the correcting of the true situation of two places, in respect of one another, is oftentimes an occasion that the same places are the more falsely situate in respect of others. Like as if there were two places eight miles distant and it were required to place a third three miles from either of them; here if we set the third in the middle, it will be four miles distant from either: but if (attempting to mend that error) we make the third to be 3 miles from the first, then will it be 5 miles from the second: And thus unavoidably, the mending of the one is the marring of the other; because the thing proposed is not possible.

And such is the error of the Plain or Common *Sea-Chart*, representing the Earth and Sea, not as a Spherical, but as the Plain Superficies; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the graduation and projection being such, the Situations and Distances of places, cannot be generally and truly expressed therein.

But the graduation and projection of *Mercators Chart*, agreeing without sensible error with the *Globe*, there may in that be described all or any parts of the World, according to their Longitudes, Latitudes, Courses, and Distances, as truly and far more conveniently for the *Mariners* use than upon the *Globe* it self; and upon such a *Chart* so described, a reckoning may be truly kept, and any error committed, may easily be discerned and amended. Whereas on the *Plain Chart*, if a man find his reckoning to disagree, he is so far from knowing how to amend it, that he can seldom conjecture where the fault was.

The neglect and want of these *Charts* hath been and is a great

imperfection in *Navigation* and *Geography*. For howsoever there be some which do daily set forth for sale Maps of the World and of the parts thereof, according to this Projection: Yet to have them truly such, and fit for Navigation, requires in the Author or maker of them good knowledge, and some competent ability of his own, or aid from others, with a greater love to the Truth then to his own profit, which may induce him to bestow such industry, time, and expence, as I have formerly noted to be requisite in such a Work.

For the furtherance whereof, and of the practice of Navigation in general; I shall endeavour in the two next Chapters to shew a methodical and orderly way of keeping a reckoning at Sea, more distinctly and exactly then hath been formerly used, and such as may aptly be set down in any Chart, and applyed in the three principal kinds of Sailing; namely, according to the *Plain Chart*, or *Mercators*, or according to the Arch of a *Great Circle*. And by a few reckonings truly set down, according to this form, the Maps of the World and of the parts thereof might be much reformed.

CHAP. VIII.

A formal and exact way of setting down and perfecting a Sea-reckoning.



Although the Course and Distance cannot be so truly and certainly known as the Latitude may be: yet we must endeavour in these also to come as near the Truth as may be, the rather for that some reckonings must necessarily depend wholly upon them. And to that end, those which in their Voyages at Sea have occasion to run far upon any Course or Courses near the Meridian, may do well to make trial of that which I have formerly set down, touching the quantity of a Degree on the Earth or Sea in our known Measure; and especially in *East-Indian* Voyages; sayling from the *Lizard* in

in the West part of *England* to *Cape de bonne Esperance* in *Africk*. they have opportunity of making an ample Experiment hereof.

But leaving this to the practice of the skilful and industrious *Sea-man*, we come now to shew an orderly and exact way of framing and keeping a reckoning at Sea: for which purpose I have made the *Table* following, which sheweth how much a ship is more Northerly or Southerly, and how much more Easterly or Westerly, by sailing upon any point or half point of the *Compass*, any number of miles proposed.

The like *Table* I made many years since, and taught the use of it in *Navigation*, whether it were then used by any other, I know not, I had it of no man; but this I speak, that if any man claim the first making and use of such an one, he may have it.

The ground of making this *Table* is the same with the former. *For as Radius is in proportion to the Distance run, So is the sine complement of the Rumb to the distance of North or South, and so is the sine of the Rumb to the distance of East or West.* Therefore here for ten miles upon any of the four points from the Meridian, we set in the second column the sine complement of that point (reduced into Degrees) and in the third the sine thereof. As the second Rumb or point from the Meridian, being 22 deg. 30 min. the sine complement thereof which is 92 39 set in the second column against 10: and the sine thereof 3827, I set there in the third column; and having done thus, for ten miles in every column, the rest may be easily drawn from them.

As in the second column, for the first half point against 10 miles finding 9952, I set the half thereof; namely 4976 against 5 miles, and the tenth part thereof, namely 995 against 1 mile, which doubled or added to it self is 1990, to be set against two miles, whereto adding the same 995, the sum is 2985 for three miles, and so for the rest.

And thus for every point and half point from the Meridian, there are three columns: In the first whereof there is set down a number of miles run upon that point or half point; the second sheweth how much the Latitude is altered; that

is, how much you are more Southerly or Northerly, by running so far upon that point or half point; the third, how much you are more Easterly or Westerly, by running that course and distance.

The Numbers set in every first column from 1 to 10, are also to be understood from 10 to 100, or from 100 to 1000, and the Figure in the fourth place of the second and third columns, answer to the figure in the first. As admit a ship run South and by West (that is (South 1 point Westerly) 165 miles) I set down this number thus; and

	100	981	195
S. W. 1.	60	588	117
point.	5	49	10
	165	161.8	32.2

looking in the Columns of the first *Rumb* against 10, (which may be understood to be 100) I find against it in the second Column 981 almost, and in the third 195,

also against 60 (that is 6) in the first Column, there is 588 in the second, and 117 in the third: also against 5 in the first Column, there is 49 in the second, and almost 10 in the third.

These set down, and summ'd up, as here appeareth, shew that a Ship running S. by W. 165 miles, is to the Southwards of the place from whence she departed 161 miles and 8 tenth parts of a mile, and to the Westwards 32 miles, and 2 tenth parts of a mile. If you desire more exactness you may use all the places,

for the first or greatest number, which is here 100.

	100	9808	1950
S. W. 1.	60	5885	1170
point.	5	490	97
	165.	161.83	32.17

As in the second Example, where the Southerly distance is 161. $\frac{83}{100}$ miles, and the Westerly 32. $\frac{17}{100}$ miles.

A Table of the Northing and Southing, Easting or Westing of every Rumb and half Rumb from the Meridian; according to the number of Miles run upon that Rumb.

	$\frac{1}{2}$ poin.	$\frac{7}{8}$ poin.	1 poin.	7 poin.	$1\frac{1}{2}$ poin.	$6\frac{1}{2}$ poin.	2 poin.	6 poin.
M	5.37 $\frac{1}{2}$	84.22 $\frac{1}{2}$	11.15	78.45	16.53	73.7 $\frac{1}{2}$	22.30	67.30
1	995	98	981	195	957	290	924	383
2	1990	196	1952	390	1914	580	1848	766
3	2986	294	2943	585	2871	870	2772	1148
4	3981	392	3923	780	3827	1161	3696	1531
5	4976	490	4904	975	4784	1451	4620	1914
6	5971	588	5885	1170	5741	1741	5544	2297
7	6966	686	6865	1365	6698	2031	6468	2680
8	7961	784	7846	1560	7655	2321	7392	3062
9	8957	882	8827	1755	8612	2612	8315	3445
10	9952	980	9808	1950	9569	2902	9239	3827

	$2\frac{1}{2}$ poin.	$5\frac{1}{2}$ poin.	3 poin.	5 poin.	$3\frac{1}{2}$ poin.	$4\frac{1}{2}$ poin.	4 poin.	4 poin.
M	28.7 $\frac{1}{2}$	61.52 $\frac{1}{2}$	33.45	56.15	39.22 $\frac{1}{2}$	50.37 $\frac{1}{2}$	45.00	45.00
1	882	471	831	555	773	634	707	707
2	1764	942	1663	1111	1546	1269	1414	1414
3	2646	1414	2494	1667	2319	1903	2121	2121
4	3528	1885	3326	2222	3092	2538	2828	2828
5	4410	2357	4158	2778	3865	3172	3535	3535
6	5292	2828	4989	3334	4638	3806	4242	4242
7	6174	3300	5820	3890	5411	4440	4949	4949
8	7056	3771	6652	4445	6184	5075	5656	5656
9	7937	4243	7483	5000	6957	5710	6364	6364
10	8819	4714	8315	5556	7730	6344	7071	7071

A larger Example may be that before set down in the last Problem of Sailing by a Great Circle from Summer-Islands to the Lizard, pag. 127.

As

As admit I sail from thence: First, $NE \frac{1}{2}$ point Easterly 600 miles, then NE by E 300 miles; East North-east half point Northerly 495 miles; East NE 390 miles; ENE , $\frac{1}{2}$ point Easterly 264 miles; E by N 210 miles; East 951 miles: These Courses and Distances I set down in such forms as here appeareth, where in the first Column there is expressed the course or point of the Compass upon which a man sails: In the second Column, the Distance of that *Rumb* from the *Meridian*: In the third Column, the Distance run upon that *Point*; In the rest, the difference of Latitude, and departure from the *Meridian* in miles and tenth parts of a mile.

Course	Rumb from me.	Dist. miles.	North.	South	East	West
$NE \frac{1}{2}$	North					
Po E .	Easterly $4 \frac{1}{2}$ P.	600	380.6		463.8	
NE by E .	N East 5 Point	300	166.7		249.4	
$ENE \frac{1}{2}$	N East $5 \frac{1}{2}$ Po.	400	188.5		352.8	
Po. N		90	42.4		79.4	
		5	2.4		4.4	
ENE by N	N East 6 Po.	300	114.8		277.2	
		90	32.4		83.1	
$ENE \frac{1}{2}$	N East $6 \frac{1}{2}$ Po.	200	58.0		191.4	
Po. E .		60	17.4		57.4	
		4	1.2		3.8	
E by N	N East 7 Po.	200	39.0		196.2	
		10	2.0		9.8	
East	East	900			951.0	
		50				
		1				
		3210	1047.4		2919.7	

(In all which is to be conceived, that the *Variations* are allowed) so that at the Foot of this reckoning, I find the summe of the North Column to be $1047\frac{4}{15}$ miles, and the sum of the East Column 2920 miles almost; the first, namely 1047 miles converted into degrees, is 17 degrees, 27 min. the difference of Latitude, which added to the Latitude of *Summer-Islands* 32 degrees 25 min. (where this reckoning began) the sum is 49 deg. 52 min. which is the Latitude of this last place where this reckoning endeth. So that according to this account, the Ship is run into the Latitude of 49 deg. 52 min. and hath altered her Longitude to the Eastwards 2920 miles, of such miles, whereof 60 make a degree of a great Circle.

Therefore, if you set down this reckoning on the *Plain Chart*, you must make a point in the *Chart* that may be in the Latitude of 49 deg. 52 min. and to the Eastwards of *Summer-Islands*, (where the reckoning began) 2920 miles; that is, you must run a parallel (with your Compasses or otherwise) on your *Chart* in the Latitude of 49 degrees 52 minutes, and cross the same by a Meridian, which may be to the Eastwards of the Meridian of *Summer-Islands* 2920 miles, and so the point of the intersection of this parallel and Meridian, is the Traverse-point or point in the *Chart*, representing the place where the ship is in the end of this Reckoning.

But if you set down this reckoning on *Mercators Chart*, you must also find a point that may be in the Latitude of 29 degrees 52 min. and may likewise be to the Eastwards of *Summer-Islands* 2920 miles, which is done by running with your compasses a parallel in the Latitude of 49 deg. 52 min. and crossing the same by a Meridian, which may be to the Eastwards of the Meridian of *Summer-Islands* 2920 miles, the point of the intersection of this parallel with that Meridian is the traverse-point, representing in the *Chart* the place where the ship then is.

For it is to be conceived in this *Chart*, that the degrees of the Meridian intercepted between the Latitudes of two places are as a Scale for those two places, to measure not only their difference of Latitude, but likewise their distance in their *Rumb*, as also the distance of their *Meridians*.

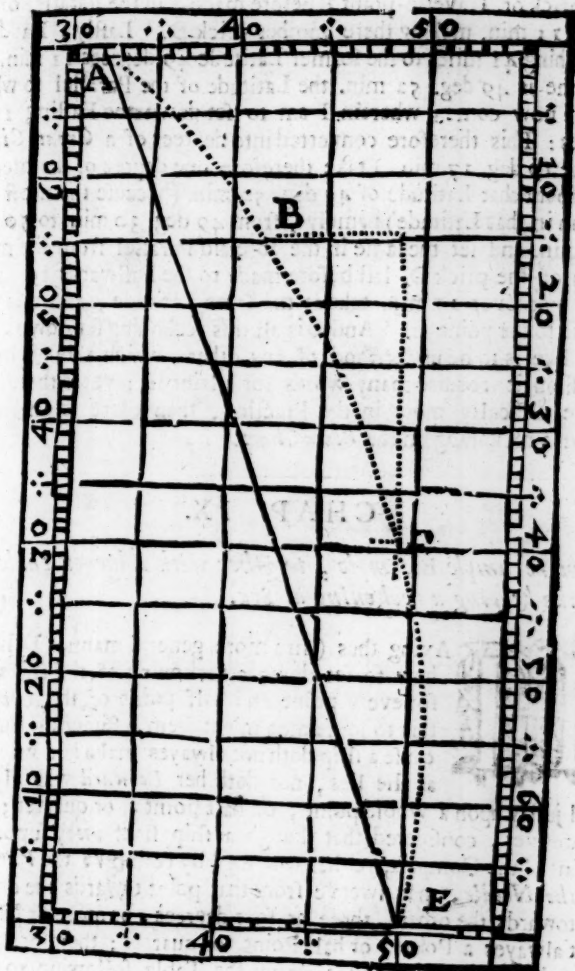
But

But because it often falls out, that in sailing from place to place, a ship runs not near the Rumb of the two places by many hundred miles, especially in sailing by the Arch of a *Great Circle*, which is the most exquisite manner of sailing, and wherein a man shifts his course often, and runs much farther in one Latitude than in another, as by the former example may appear. Therefore once in three or four dayes, or so often as you alter your Course much, you may transfer or set down your Reckoning out of your Book into your *Chart*. As in transferring the former example, you may set down the Northing and Easting of every of the Courses severally; but for brevities sake we will bring them into three parts (and so also we shall not much erre.)

And thus for the two first Courses, namely *NE* $\frac{1}{2}$ point Easterly 600 miles, and *NE by E* 300 miles, I find in the North column 547 miles; and in the East column 713 miles: also for the three next Courses summing up the North and East columns, I find the Northing to be 459 miles; and the Easting 1050 miles. Also for the two last Courses, I find the Northing to be 41 miles, and the Easting 1157 miles.

North	East.
547	713
459	1050
41	1157
1047	2920

Now to transfer these into the *Chart*, I consider that 547 miles is 9 degrees 7 minutes, which is added to the former Latitude 32 deg. 25 min. makes latitude 41 deg. 32 min. In which Latitude I run a parallel, then considering that 713 miles is 11 deg. 53 min. I take this 11 deg. 53 min. in the Meridian, as much above the one Latitude, as beneath the other, namely, from 31 deg. 0 min. to 42 degrees 53 minutes, and this I set in the foresaid parallel from the Meridian of *Summer-Islands* to the Eastwards, and there make the point B, then reducing 459 miles into deg. it makes 7 deg. 39 min. which added to 41 deg. 32 min. makes Latitude 49 deg. 11 min. Also the Easting 1050 miles are 17 deg. 30 min. the half whereof 8 deg. 45 min. I take in the Meridian from above 41 deg. 32 min. beneath 49 deg. 11 minutes, namely, from 41 deg. 20 min. to 50 deg. 5 min. And this being doubled (because it is but the half) I set from the Meridian of the



the prick or Traverse-point B before made, in the Parallel of 49 deg. 11 min. making there another prick D. Lastly, I add the Northing 41 miles to the former Latitude 49 degrees 11 min. the summe is 49 deg. 52 min. the Latitude of the Parallel to which I am now come, wherein I am to set down the Easting 1157 miles: This therefore converted into degrees of a *Great Circle*, make 19 deg. 17 min. I take therefore one degree of the meridian, about that Latitude of 49 deg. 52 min. (because the most part is run in that Latitude) namely, from 49 deg. 30 min. to 50 deg. 30 min. and set the same in the foresaid Parallel from the meridian of the prick D. last before made to the Eastwards 19 times, and moreover 17 min. take at the same Latitude, and this reacheth to the point E. And so is all this reckoning set down, and the like is to be understood of any other, which though in expression it require many words for plainness; yet is there very little difficulty more in the Practice, than there is in setting down a reckoning on the *Plain Chart*.

CHAP. IX.

A more ample Example, together with a larger Table for the keeping a reckoning at Sea.



Having thus (in a more general manner) shewed how to set down a reckoning of the ships way, for every point and half point of the *Compass*, this to some men might seem sufficient: But because a ship doth not alwayes make her way good as she lies, nor doth her *Leeward* way alwayes fall justly upon a whole point, or half point, or quarter; And moreover, considered that though a ship steer away upon any point of the *Compass*, yet her true way, by reason of the *Variation of the Needle*, may swerve from that point towards the one side or towards the other, three or four degrees, or more or less, and not alwayes a Point, or half Point, or quarter: therefore I have thought it requisite to set down the Table following to every single

single Degree: and that a man might the more readily with one or two Entrances have his desire, I have also enlarged the number of miles unto 100. The ground and way of making this Table differs not from the former, and it is to be used almost in the self-same manner, wherefore we shall use the more brevity in handling of it.

Here followeth a Table of the Northing or Southing, Easting or Westing of Every Degree from the Meridian, according to the number of Miles run upon that Degree, which for brevity sake we will call - - -

A
TABLE
FOR THE
DIFFERENCE
OF
LATITUDE
AND
Departure from the Meridian.

M	1 d.	89 d.	M	1 d.	89 d.	Min.	1 d.	89 d.
1	10	0	35	350	6	69	690	12
2	20	0	36	360	7	70	700	12
3	30	0	37	370	7	71	710	13
4	40	1	38	380	7	72	720	13
5	50	1	39	390	7	73	730	13
6	60	1	40	400	7	74	740	13
7	70	1	41	410	7	75	750	13
8	80	1	42	420	7	75	760	13
9	90	2	43	430	8	77	770	14
10	100	2	44	440	8	78	780	14
11	110	2	45	450	8	79	790	14
12	120	2	46	460	8	80	800	14
13	130	2	47	470	8	81	810	14
14	140	2	48	480	9	82	820	14
15	150	3	49	490	9	83	830	15
16	160	3	50	500	9	84	840	15
17	170	3	51	510	9	85	850	15
18	180	3	52	520	9	86	860	15
19	190	3	53	530	9	87	870	15
20	200	4	54	540	10	88	880	15
21	210	4	55	550	10	89	890	15
22	220	4	56	560	10	90	900	16
23	230	4	57	570	10	91	910	16
24	240	4	58	580	10	92	920	16
25	250	4	59	590	10	93	930	16
26	260	5	60	600	11	94	940	17
27	270	5	61	610	11	95	950	17
28	280	5	62	620	11	96	960	17
29	290	5	63	630	11	97	970	17
30	300	5	64	640	11	98	980	17
31	310	5	65	650	12	99	990	17
32	320	6	66	660	12	100	1000	18
33	330	6	67	670	12	200	2000	35
34	340	6	68	680	12	300	3000	53

M	2d.	8d.	M	2d.	8d.	Min.	2d.	8d.
1	10	0	35	350	12	69	690	24
2	20	1	36	360	13	70	700	24
3	30	1	37	370	13	71	710	25
4	40	1	38	380	13	72	720	25
5	50	2	39	390	14	73	730	25
6	60	2	40	400	14	74	740	26
7	70	2	41	410	14	75	750	26
8	80	3	42	420	15	76	760	26
9	90	3	43	430	15	77	770	27
10	100	3	44	440	15	78	780	27
11	110	4	45	450	16	79	790	28
12	120	4	46	460	16	80	800	28
13	130	4	47	470	16	81	809	28
14	140	5	48	480	17	82	819	29
15	150	5	49	490	17	83	829	29
16	160	6	50	500	17	84	839	29
17	170	6	51	510	18	85	849	30
18	180	6	52	520	18	86	859	30
19	190	7	53	530	18	87	869	30
20	200	7	54	540	19	88	879	31
21	210	7	55	550	19	89	889	31
22	220	8	56	560	19	90	899	31
23	230	8	57	570	20	91	909	32
24	240	8	58	580	20	92	919	32
25	250	9	59	590	20	93	929	32
26	260	9	60	600	21	94	939	33
27	270	9	61	610	21	95	949	33
28	280	10	62	620	22	96	959	34
29	290	10	63	630	22	97	969	34
30	300	10	64	640	22	98	979	34
31	310	11	65	650	23	99	989	35
32	320	11	66	660	23	100	999	35
33	330	11	67	670	23	200	1999	70
34	340	12	68	680	24	300	2998	105

M	3 d.	87 d.	M	3 d.	87 d.	Min.	3 d.	87 d.
1	10	1	35	350	18	69	689	36
2	20	1	36	360	19	70	699	37
3	30	1	37	370	19	71	709	37
4	40	2	38	380	20	72	719	38
5	50	2	39	390	20	73	729	38
6	60	3	40	400	21	74	739	39
7	70	4	41	410	21	75	749	39
8	80	4	42	420	22	76	759	40
9	90	5	43	430	22	77	769	40
10	100	5	44	440	23	78	779	41
11	110	6	45	450	23	79	789	41
12	120	6	46	460	24	80	799	42
13	130	7	47	470	24	81	809	42
14	140	7	48	480	25	82	819	43
15	150	8	49	490	26	83	829	43
16	160	8	50	500	26	84	839	44
17	170	9	51	509	27	85	849	44
18	180	9	52	519	27	86	859	45
19	190	10	53	529	28	87	869	45
20	200	10	54	539	28	88	879	46
21	210	11	55	549	29	89	889	46
22	220	11	56	559	29	90	899	47
23	230	12	57	569	30	91	909	48
24	240	12	58	579	30	92	919	48
25	250	13	59	589	31	93	929	49
26	260	13	60	599	31	94	939	49
27	270	14	61	609	32	95	949	50
28	280	15	62	619	32	96	959	50
29	290	15	63	629	33	97	969	51
30	300	16	64	639	33	98	979	51
31	310	16	65	649	34	99	989	52
32	320	17	66	659	35	100	999	52
33	330	17	67	669	35	200	1997	105
34	340	18	68	679	36	300	2996	157

M	4 d.	6 d.	M	4 d.	8 d.	Min.	4 d.	8 d.
1	10	1	35	349	25	69	688	48
2	20	1	36	359	25	70	698	49
3	30	2	37	369	26	71	708	50
4	40	3	38	379	27	72	718	50
5	50	3	39	389	27	73	728	51
6	60	4	40	499	28	74	738	52
7	70	5	41	409	29	75	748	52
8	80	6	42	419	29	76	758	53
9	90	6	43	429	30	77	768	54
10	100	7	44	439	31	78	778	55
11	110	8	45	449	31	79	788	55
12	120	8	46	459	32	80	798	56
13	130	9	47	469	33	81	808	57
14	140	10	48	479	34	82	818	57
15	150	10	49	489	34	83	828	58
16	160	11	50	499	35	84	838	59
17	170	12	51	509	36	85	848	59
18	180	13	52	519	36	86	858	60
19	190	13	53	529	37	87	868	61
20	200	14	54	539	38	88	878	61
21	209	15	55	549	38	89	888	62
22	219	15	56	559	39	90	898	63
23	229	16	57	569	40	91	908	63
24	239	17	58	579	40	92	918	64
25	249	17	59	589	41	93	928	65
26	259	18	60	599	42	94	938	66
27	269	19	61	609	43	95	948	66
28	279	20	62	619	43	96	958	67
29	289	20	63	629	44	97	968	68
30	299	21	64	639	45	98	978	68
31	309	22	65	648	45	99	988	69
32	319	22	66	658	46	100	998	70
33	329	23	67	668	47	200	1995	140
34	339	24	68	678	48	300	2993	209

M	5 d.	85 d.	M	5 d.	85 d.	Min.	5 d.	85 d.
1	10	1	35	349	30	69	687	60
2	20	2	36	359	31	70	697	61
3	30	3	37	369	32	71	707	62
4	40	3	38	379	33	72	717	63
5	50	4	39	388	34	73	727	64
6	60	5	40	398	35	74	737	65
7	70	6	41	408	36	75	747	65
8	80	7	42	418	37	76	757	66
9	90	8	43	428	37	77	767	67
10	100	9	44	438	38	78	777	68
11	110	10	45	448	39	79	787	69
12	120	10	46	458	40	80	797	70
13	130	11	47	458	41	81	807	71
14	140	12	48	478	42	82	817	71
15	150	13	49	488	43	83	827	72
16	159	14	50	498	44	84	837	73
17	169	15	51	508	45	85	847	74
18	179	16	52	518	45	86	857	75
19	189	17	53	528	46	87	857	76
20	199	17	54	538	47	88	877	77
21	209	18	55	548	48	89	887	78
22	219	19	56	558	49	90	897	78
23	229	20	57	568	50	91	907	79
24	239	21	58	578	51	92	916	80
25	249	22	59	588	52	93	926	81
26	259	23	60	598	52	94	936	82
27	269	24	61	608	53	95	946	83
28	279	24	62	618	54	96	956	84
29	289	25	63	628	55	97	966	84
30	299	26	64	638	56	98	976	85
31	309	27	65	648	57	99	986	86
32	319	28	66	658	58	100	996	87
33	329	29	67	668	58	200	1992	174
34	339	30	68	678	59	300	2989	162

M	6d.	84 d.	M	6d.	84d.	Min.	6d.	84 d.
1	10	1	35	346	36	69	686	72
2	20	2	36	358	38	70	696	73
3	30	3	37	368	39	71	706	74
4	40	4	38	378	40	72	716	75
5	50	5	39	388	41	73	726	76
6	60	6	40	398	42	74	736	77
7	70	7	41	408	43	75	746	78
8	80	8	42	418	44	76	756	79
9	89	9	43	428	45	77	766	80
10	99	10	44	438	46	78	776	81
11	109	11	45	447	47	79	786	82
12	119	12	46	457	48	80	796	83
13	129	14	47	467	49	81	805	85
14	139	15	48	477	50	82	815	86
15	149	16	49	487	51	83	825	87
16	159	17	50	497	52	84	835	88
17	169	18	51	507	53	85	845	89
18	179	19	52	517	54	86	855	90
19	189	20	53	527	55	87	865	91
20	199	21	54	537	56	88	875	92
21	209	22	55	547	57	89	885	93
22	219	23	56	557	58	90	895	94
23	229	24	57	567	59	91	905	95
24	239	25	58	577	61	92	915	96
25	249	26	59	587	62	93	925	97
26	259	27	60	597	63	94	935	98
27	268	28	61	607	64	95	945	99
28	278	29	62	617	65	96	955	100
29	288	30	63	627	65	97	965	101
30	298	31	64	637	67	98	975	102
31	308	32	65	646	68	99	985	103
32	318	33	66	656	69	100	995	104
33	328	34	67	666	70	200	1989	209
34	338	35	68	676	71	300	2983	313

M	7 d.	83 d.	M	7 d.	83 d.	Min.	7 d.	83 d.
1	10	1	35	347	43	69	685	84
2	20	2	36	357	44	70	695	85
3	30	4	37	357	45	71	705	87
4	40	5	38	377	46	72	715	88
5	50	6	39	387	48	73	725	89
6	60	7	40	397	49	74	734	90
7	69	8	41	407	50	75	744	92
8	79	10	42	417	51	76	754	93
9	89	11	43	427	52	77	764	94
10	99	12	44	437	54	78	774	25
11	109	13	46	447	55	79	784	96
12	119	15	46	456	56	80	794	98
13	129	16	47	466	57	81	804	99
14	139	17	48	476	59	82	814	100
15	149	18	49	486	60	83	824	101
16	159	20	50	496	61	84	834	103
17	169	21	51	506	62	85	844	104
18	179	22	52	516	63	86	854	105
19	189	23	53	526	65	87	863	106
20	199	24	54	536	66	88	873	107
21	208	26	55	546	67	89	883	109
22	218	27	56	556	68	90	893	110
23	228	28	57	566	69	91	903	111
24	238	29	58	576	71	92	913	112
25	248	30	59	586	72	93	923	113
26	258	32	60	596	73	94	933	115
27	268	33	61	605	74	95	943	116
28	278	34	62	615	76	96	253	117
29	288	35	63	625	77	97	963	118
30	298	37	64	635	48	98	973	120
31	308	38	65	645	79	99	983	121
32	318	39	66	655	81	100	993	122
33	327	40	67	665	82	200	1985	244
34	337	41	68	675	83	300	2977	366

M	8d.	82 d.	M	8d.	82d.	Min.	8d.	82 d.
1	10	1	35	347	49	69	683	96
2	100	3	36	357	50	70	693	97
3	30	4	37	366	51	71	703	99
4	40	6	38	376	53	72	713	100
5	50	7	39	386	54	73	723	101
6	59	8	40	396	56	74	733	103
7	69	10	41	406	57	75	743	104
8	79	11	42	416	58	76	753	106
9	89	13	43	426	60	77	763	107
10	99	14	44	436	61	78	772	109
11	109	15	45	446	63	79	782	110
12	119	17	46	456	64	80	792	111
13	129	18	47	465	65	81	802	113
14	139	19	48	475	67	82	812	114
15	148	21	49	485	68	83	822	115
16	158	22	50	495	70	84	832	117
17	168	24	51	505	71	85	842	118
18	178	25	52	515	72	86	852	120
19	188	26	53	525	74	87	862	121
20	198	28	54	535	75	88	872	122
21	208	29	55	545	77	89	882	124
22	218	31	56	555	78	90	892	125
23	228	32	57	565	79	91	902	127
24	238	33	58	574	81	92	912	128
25	248	35	59	584	82	93	922	129
26	257	36	60	594	83	94	932	131
27	267	38	61	604	85	95	942	132
28	277	39	62	614	86	96	952	134
29	287	40	63	624	88	97	962	135
30	297	42	64	634	89	98	970	136
31	307	43	65	644	90	99	980	138
32	317	44	66	654	92	100	990	139
33	327	46	67	664	93	200	1981	278
34	337	47	68	673	95	300	2971	418

M	9 d.	81 d.	M	9 d.	81 d.	Min.	9 d.	81 d.
1	10	2	35	346	55	69	682	108
2	20	3	36	356	56	70	691	109
3	30	5	37	366	58	71	701	111
4	40	6	38	375	59	72	711	112
5	49	8	39	385	61	73	721	114
6	59	9	40	395	63	74	731	116
7	69	11	41	405	64	75	741	117
8	79	13	42	415	66	76	751	119
9	89	14	43	425	67	77	761	120
10	99	16	44	435	69	78	770	122
11	109	17	45	445	70	79	780	124
12	119	19	46	454	72	80	790	125
13	129	20	47	464	73	81	800	127
14	138	22	48	474	75	82	810	128
15	148	23	49	484	77	83	820	130
16	158	25	50	494	78	84	830	131
17	168	26	51	504	80	85	840	133
18	178	28	52	514	81	86	850	134
19	188	30	53	524	83	87	859	136
20	198	31	54	534	84	88	869	138
21	208	33	55	543	86	89	879	139
22	217	34	56	553	88	90	889	141
23	227	36	57	563	89	91	899	142
24	237	37	58	573	91	92	909	144
25	247	39	59	583	92	93	919	145
26	257	41	60	593	94	94	929	147
27	267	42	61	603	95	95	938	148
28	277	44	62	612	97	96	948	150
29	287	45	63	622	98	97	958	152
30	297	47	64	632	100	98	968	153
31	306	48	65	642	102	99	978	155
32	316	50	66	652	103	100	988	156
33	326	51	67	662	105	200	1975	213
34	336	53	68	672	106	300	2963	369

M	10 d	80 d	M	10 d	80 d	Min.	10 d	80 d
1	10	2	35	345	61	69	680	120
2	20	3	36	355	62	70	689	121
3	30	3	37	365	64	71	699	123
4	39	7	38	374	66	72	709	125
5	49	9	39	384	68	73	719	127
6	59	10	40	394	69	74	729	128
7	69	12	41	404	71	75	739	130
8	79	14	42	414	73	76	749	132
9	89	16	43	424	75	77	758	133
10	99	17	44	437	76	78	768	135
11	108	19	45	445	78	79	778	137
12	118	21	46	453	80	80	788	139
13	128	23	47	463	81	81	798	141
14	138	24	48	473	83	82	808	142
15	148	26	49	483	85	83	817	144
16	158	28	50	492	87	84	827	146
17	168	30	51	502	88	85	837	148
18	177	31	52	512	90	86	847	149
19	187	33	53	522	92	87	857	151
20	197	35	54	532	94	88	867	153
21	207	36	55	542	95	89	876	154
22	217	38	56	552	97	90	886	156
23	227	40	57	561	99	91	896	158
24	235	42	58	571	101	92	906	160
25	246	43	59	581	102	93	916	161
26	256	45	60	591	104	94	926	163
27	266	47	61	601	106	95	936	165
28	276	49	62	611	108	96	946	167
29	286	50	63	620	109	97	955	168
30	296	52	64	630	111	98	965	170
31	305	54	65	640	113	99	975	172
32	315	55	66	650	115	100	985	174
33	325	57	67	660	116	200	1970	347
34	333	59	68	670	118	300	2954	521

M	11 d	79 d.	M	11 d	79 d	Min.	11 d.	81 d.
1	19	8	35	343	67	69	677	132
2	20	4	36	353	69	70	687	134
3	29	6	37	363	71	71	697	135
4	39	8	38	373	72	72	707	137
5	49	9	39	383	74	73	716	139
6	59	11	40	393	76	74	726	141
7	69	13	41	402	78	75	736	143
8	78	15	42	412	80	76	746	145
9	88	17	43	422	82	77	756	147
10	98	19	44	432	84	78	765	149
11	108	21	45	442	86	79	775	151
12	118	23	46	452	88	80	785	153
13	128	25	47	461	90	81	795	154
14	137	27	48	471	92	82	805	156
15	147	29	49	481	93	83	815	158
16	157	30	50	491	95	84	824	150
17	167	32	51	501	97	85	834	162
18	177	34	52	510	99	86	844	164
19	186	36	53	520	101	87	854	166
20	196	38	54	530	103	88	864	168
21	206	40	55	540	105	89	873	170
22	216	42	56	550	107	90	883	172
23	226	44	57	559	109	91	893	174
24	236	46	58	569	111	92	903	176
25	245	48	59	579	112	93	913	177
26	253	50	60	589	114	94	923	179
27	263	51	61	599	116	95	932	181
28	273	53	62	609	118	96	942	183
29	283	55	63	618	120	97	952	185
30	294	57	64	628	122	98	962	187
31	304	59	65	638	124	99	972	189
32	314	61	66	648	126	100	981	191
33	324	63	67	658	128	100	1963	382
34	334	65	68	668	130	300	2944	572

M	12 d	78 d	M	12 d	78 d	Min.	12 d	78 d
1	10	2	35	342	73	69	675	144
2	20	4	36	352	75	70	685	146
3	29	6	37	362	77	71	694	148
4	39	8	38	372	79	72	704	150
5	49	10	39	381	81	73	714	152
6	59	12	40	391	83	74	724	154
7	68	15	41	401	85	75	734	156
8	78	17	42	411	87	76	743	158
9	88	19	43	420	90	77	753	160
10	98	21	44	430	92	78	763	162
11	108	23	45	440	94	79	773	164
12	117	25	46	450	96	80	783	166
13	127	27	47	460	98	81	792	168
14	137	29	48	470	100	82	802	170
15	147	31	49	479	102	83	812	173
16	156	33	50	489	104	84	822	175
17	166	36	51	499	106	85	832	177
18	176	38	52	509	108	86	841	179
19	186	40	53	518	110	87	851	181
20	196	42	54	528	112	88	861	183
21	205	44	55	538	114	89	871	185
22	215	46	56	548	116	90	880	187
23	225	48	57	558	118	91	890	189
24	235	50	58	567	121	92	900	191
25	245	52	59	577	123	93	910	193
26	254	54	60	587	125	94	920	195
27	264	56	61	597	127	95	929	197
28	274	58	62	607	129	96	939	200
29	284	62	63	616	131	97	949	202
30	293	60	64	626	133	98	959	204
31	303	64	65	636	135	99	968	206
32	313	66	66	646	137	100	978	208
33	323	69	67	655	140	200	1956	416
34	333	71	68	665	142	300	2934	624

M	13d	77 d	M	13d	77d.	Min.	13 d.	77 d.
1	10	2	35	341	79	69	672	155
2	20	4	36	351	81	70	682	157
3	29	7	37	351	83	71	692	160
4	39	9	38	370	86	72	702	162
5	49	11	39	380	88	73	711	164
6	59	13	40	390	90	74	721	166
7	68	16	41	400	92	75	731	169
8	78	18	42	409	94	76	741	171
9	88	20	43	419	97	77	750	173
10	98	22	44	429	99	78	760	175
11	107	25	45	438	101	79	770	178
12	117	27	46	448	103	80	780	180
13	127	29	47	458	106	81	789	182
14	136	31	48	468	108	82	799	184
15	146	34	49	477	110	83	809	187
16	156	36	50	487	112	84	818	189
17	166	38	51	497	125	85	828	191
18	176	40	52	507	117	86	838	193
19	185	43	53	516	119	87	848	196
20	195	45	54	526	121	88	857	198
21	205	47	55	536	124	89	867	200
22	215	49	56	546	126	90	877	202
23	224	52	57	555	128	91	887	205
24	234	54	58	565	130	92	896	207
25	244	56	59	575	133	93	906	209
26	254	58	60	585	135	94	915	211
27	263	61	61	594	137	95	926	214
28	273	63	62	604	140	96	935	216
29	283	65	63	614	142	97	945	218
30	292	67	64	624	144	98	255	221
31	302	70	65	634	146	99	965	223
32	312	72	66	643	148	100	974	225
33	322	74	67	653	151	200	1949	450
34	331	76	68	663	153	300	2923	675

M	14 d	76 d	M	14 d	76 d	Min.	14 d	76 d
1	10	2	35	340	85	69	669	156
2	19	5	36	349	87	70	679	169
3	29	7	37	359	90	71	689	172
4	39	10	38	369	92	72	698	174
5	48	12	39	378	94	73	708	177
6	58	14	40	388	97	74	718	179
7	68	17	41	398	99	75	728	182
8	78	19	42	407	102	76	737	184
9	87	22	43	417	104	77	747	187
10	97	24	44	427	107	78	757	189
11	107	27	45	437	119	79	766	191
12	116	29	46	446	111	80	776	194
13	126	31	47	456	114	81	786	195
14	136	34	48	466	116	82	796	197
15	146	36	49	475	119	83	805	200
16	155	39	50	485	121	84	815	202
17	165	41	51	495	123	85	824	205
18	175	44	52	504	126	86	834	207
19	184	46	53	514	128	87	844	209
20	194	48	54	524	131	88	854	213
21	204	51	55	534	133	89	864	215
22	213	53	56	543	136	90	873	218
23	223	56	57	553	138	91	883	220
24	233	58	58	563	140	92	893	223
25	242	60	59	572	143	93	902	225
26	252	63	60	582	145	94	912	227
27	262	65	61	592	148	95	921	230
28	272	68	62	601	150	96	931	232
29	281	70	63	611	153	97	941	235
30	291	73	64	621	155	98	951	237
31	301	75	65	631	157	99	960	240
32	310	77	66	640	160	100	970	242
33	320	80	67	650	162	200	1941	284
34	330	82	68	660	165	300	2911	226

M	15d	75 d.	M	15d	75d.	Min.	15 d.	75 d.
1	10	3	35	338	91	69	666	179
2	19	5	36	348	93	70	676	181
3	29	8	37	357	96	71	686	184
4	39	10	38	367	98	72	696	186
5	48	13	39	377	101	73	705	189
6	58	16	40	386	103	74	715	192
7	68	18	41	396	106	75	724	194
8	77	21	42	406	109	76	734	197
9	87	23	43	415	111	77	744	200
10	97	26	44	425	114	78	754	202
11	106	28	45	435	116	79	763	205
12	116	31	46	444	119	80	773	207
13	126	34	47	454	123	81	783	210
14	135	36	48	464	125	82	792	212
15	145	39	49	473	128	83	802	215
16	155	41	50	483	129	84	811	217
17	164	44	51	493	132	85	821	220
18	174	47	52	502	135	86	831	223
19	183	49	53	512	137	87	840	225
20	193	52	54	522	140	88	850	228
21	203	54	55	531	142	89	860	230
22	213	57	56	541	145	90	869	233
23	222	60	57	551	148	91	879	236
24	233	62	58	560	150	92	889	238
25	242	65	59	570	153	93	898	241
26	251	67	60	580	155	94	908	243
27	261	70	61	589	158	95	918	246
28	271	73	62	599	160	96	927	248
29	280	75	63	608	163	97	937	251
30	290	78	64	618	166	98	947	254
31	299	80	65	628	168	99	256	256
32	309	83	66	638	171	100	966	259
33	319	85	67	647	174	200	1932	518
34	328	88	68	657	176	300	2898	776

M	16 d	74 d	M	16 d	74 d	Min.	16 d	74 d
1	10	3	35	336	97	69	663	190
2	19	6	36	346	99	70	673	193
3	29	8	37	356	102	71	682	196
4	38	11	38	365	105	72	692	199
5	48	14	39	375	107	73	702	201
6	58	17	40	384	110	74	711	204
7	67	19	41	394	113	75	721	207
8	77	22	42	404	116	76	731	210
9	86	25	43	413	119	77	740	213
10	96	28	44	423	121	78	750	215
11	106	30	45	432	124	79	759	218
12	115	33	46	442	127	80	769	220
13	125	36	47	452	130	81	779	223
14	135	39	48	461	132	82	788	226
15	144	41	49	471	135	83	798	229
16	154	44	50	481	138	84	807	232
17	163	47	51	490	141	85	817	235
18	173	50	52	500	143	86	827	237
19	183	53	53	509	146	87	836	240
20	192	55	54	519	149	88	846	243
21	202	58	55	529	151	89	856	245
22	211	61	56	538	154	90	865	248
23	222	63	57	548	157	91	875	251
24	231	66	58	557	160	92	884	254
25	240	69	59	567	163	93	894	257
26	250	72	60	577	165	94	904	259
27	259	75	61	586	168	95	913	262
28	269	77	62	596	171	96	923	265
29	279	80	63	606	174	97	932	267
30	288	83	64	615	177	98	942	270
31	298	85	65	625	179	99	952	273
32	308	88	66	634	182	100	961	276
33	317	91	67	644	185	200	1923	551
34	327	94	68	654	188	300	2884	827

M	17d	73 d.	M	17d	73d.	Min.	17 d.	73 d.
1	10	3	35	335	102	69	660	202
2	19	6	36	344	105	70	669	205
3	29	9	37	354	108	71	679	207
4	38	12	38	363	111	72	688	210
5	48	15	39	373	114	73	698	213
6	57	17	40	383	117	74	708	216
7	67	20	41	392	120	75	717	219
8	76	23	42	402	123	76	727	222
9	86	26	43	411	126	77	736	225
10	96	29	44	421	129	78	746	228
11	105	32	45	430	132	79	755	231
12	115	35	46	440	134	80	765	234
13	124	38	47	449	137	81	775	237
14	134	41	48	459	140	82	784	240
15	143	44	49	469	143	83	794	243
16	153	47	50	478	146	84	803	246
17	162	50	51	488	149	85	813	248
18	172	52	52	497	152	86	822	251
19	182	55	53	507	155	87	832	254
20	191	58	54	516	158	88	842	257
21	201	61	55	526	161	89	851	260
22	210	64	56	535	164	90	861	263
23	220	67	57	545	167	91	870	266
24	230	70	58	554	170	92	880	269
25	239	73	59	564	172	93	889	272
26	249	76	60	574	175	94	899	275
27	258	79	61	583	178	95	908	278
28	268	82	62	592	181	96	918	281
29	277	85	63	602	184	97	927	284
30	287	88	64	612	187	98	937	287
31	296	91	65	622	190	99	947	289
32	306	93	66	631	193	100	956	292
33	316	96	67	641	196	200	1913	585
34	325	99	68	650	199	300	2869	877

M	18d	72 d.	M	18d	72d.	Min.	18d.	72 d.
1	10	3	35	333	108	69	656	213
2	19	6	36	342	111	70	666	216
3	28	9	37	352	114	71	675	219
4	38	12	38	361	117	72	685	222
5	47	15	39	371	120	73	694	225
6	57	18	40	380	124	74	704	229
7	66	22	41	390	127	75	713	232
8	76	25	42	398	130	76	723	235
9	85	28	43	408	133	77	732	238
10	95	31	44	417	136	78	742	241
11	104	34	45	427	139	79	751	244
12	114	37	46	436	142	80	761	247
13	123	40	47	446	145	81	770	250
14	133	43	48	455	148	82	780	253
15	142	46	49	465	151	83	789	256
16	152	50	50	476	154	84	799	260
17	161	53	51	485	158	85	808	263
18	171	56	52	495	161	86	818	266
19	180	59	53	504	164	87	827	269
20	190	62	54	514	167	88	837	272
21	200	65	55	523	170	89	846	275
22	209	68	56	533	173	90	856	278
23	219	71	57	542	176	91	865	281
24	228	74	58	552	179	92	875	284
25	238	77	59	561	182	93	884	287
26	247	81	60	571	185	94	894	290
27	257	84	61	580	188	95	903	293
28	266	87	62	598	192	96	913	297
29	277	90	63	599	195	97	922	300
30	285	93	64	609	198	98	932	303
31	295	96	65	618	201	99	941	306
32	304	99	66	628	204	100	951	309
33	314	102	67	637	207	200	1902	618
34	323	105	68	647	210	300	2850	927

M	19d	71 d.	M	19d	71 d.	Min.	19 d.	71 d.
1	9	3	35	331	114	69	652	225
2	19	6	36	340	117	70	662	228
3	28	10	37	350	121	71	671	231
4	38	13	38	359	124	72	681	234
5	47	16	39	369	127	73	690	238
6	57	20	40	378	130	74	699	241
7	66	23	41	388	134	75	709	244
8	75	26	42	397	137	76	718	247
9	85	29	43	407	140	77	728	251
10	94	33	44	416	143	78	737	254
11	104	36	45	425	147	79	747	257
12	113	39	46	435	150	80	756	261
13	123	42	47	444	153	81	766	264
14	132	46	48	454	156	82	775	267
15	142	49	49	463	160	83	785	270
16	151	52	50	473	163	84	794	274
17	161	55	51	482	166	85	804	277
18	170	59	52	492	169	86	813	280
19	180	62	53	501	173	87	822	283
20	189	65	54	510	176	88	832	287
21	199	68	55	520	179	89	841	290
22	208	72	56	529	182	90	851	293
23	217	75	57	539	186	91	860	296
24	227	78	58	548	189	92	870	300
25	236	82	59	558	192	93	879	303
26	246	85	60	567	195	94	889	306
27	255	88	61	577	199	95	898	309
28	265	91	62	586	202	96	908	313
29	274	94	63	596	205	97	917	316
30	284	98	64	605	208	98	926	319
31	293	101	65	615	212	99	936	322
32	303	104	66	624	215	100	945	326
33	312	107	67	634	218	200	1891	651
34	321	111	68	643	222	300	2836	977

M	20d	70 d.	M	20 d	70d.	Min.	20d.	70 d.
1	9	3	35	329	120	69	648	230
2	19	7	36	338	123	70	658	239
3	28	10	37	348	125	71	667	243
4	38	14	38	357	130	72	677	246
5	47	17	39	366	133	73	686	250
6	56	20	40	376	137	74	695	253
7	66	24	41	385	140	75	705	256
8	75	27	42	395	144	76	714	260
9	85	31	43	404	147	77	724	263
10	94	34	44	413	150	78	733	267
11	103	38	45	423	154	79	742	270
12	113	41	46	432	157	80	752	274
13	122	44	47	442	161	81	761	277
14	132	48	48	451	164	82	771	280
15	141	51	49	460	168	83	780	284
16	150	55	50	470	171	84	789	287
17	160	58	51	479	174	85	800	291
18	169	61	52	489	178	86	808	294
19	179	65	53	498	181	87	818	298
20	188	68	54	507	185	88	827	301
21	197	72	55	517	188	89	836	304
22	207	75	56	526	191	90	846	308
23	216	79	57	536	195	91	855	311
24	226	82	58	545	198	92	864	315
25	235	85	59	554	202	93	874	318
26	244	89	60	564	205	94	883	321
27	254	92	61	573	209	95	893	325
28	263	96	62	583	212	96	902	328
29	272	100	63	592	215	97	912	332
30	282	103	64	601	219	98	921	335
31	291	106	65	611	222	99	930	339
32	301	109	66	620	226	100	940	342
33	310	113	67	630	229	200	1879	684
34	319	116	68	639	233	300	2819	1026

M	21 d	69 d	M	21 d	69 d	Min.	21 d	69 d
1	9	4	35	327	325	69	644	247
2	19	7	36	336	129	70	653	251
3	28	11	37	345	132	71	663	254
4	37	14	38	355	136	72	671	258
5	47	18	39	364	140	73	681	262
6	56	21	40	373	143	74	691	265
7	65	25	41	383	147	75	700	269
8	74	29	42	392	150	76	709	272
9	84	32	43	401	154	77	719	276
10	93	36	44	411	158	78	728	279
11	103	39	45	420	161	79	737	283
12	112	43	46	429	165	80	747	287
13	121	47	47	439	168	81	756	290
14	131	50	48	448	172	82	766	294
15	140	54	49	457	176	83	775	297
16	149	57	50	467	179	84	784	301
17	159	61	51	476	183	85	794	305
18	168	64	52	485	186	86	803	308
19	177	68	53	495	190	87	812	322
20	187	72	54	504	193	88	822	315
21	196	75	55	513	197	89	831	319
22	205	79	56	523	201	90	840	323
23	215	82	57	532	204	91	849	326
24	225	86	58	541	208	92	859	330
25	233	90	59	551	211	93	868	333
26	243	93	60	560	215	94	877	337
27	252	97	61	569	219	95	887	340
28	261	100	62	579	222	96	896	344
29	271	104	63	588	226	97	905	348
30	280	107	64	598	229	98	915	351
31	289	111	65	607	233	99	924	355
32	299	115	66	616	236	100	934	358
33	308	118	67	626	240	200	1867	717
34	317	122	68	635	244	300	1801	1075

M	22 d.	68 d.	M	22 d.	68 d.	M	Min.	22 d.	68 d.
1	9	4	35	324	131	69	640	259	
2	19	7	36	334	135	70	649	262	
3	28	11	37	343	139	71	658	266	
4	37	15	38	352	142	72	667	270	
5	46	19	39	361	146	73	677	274	
6	56	22	40	371	150	74	686	277	
7	65	25	41	380	154	75	695	281	
8	74	30	42	389	157	76	705	285	
9	83	34	43	399	161	77	714	289	
10	93	37	44	408	165	78	723	292	
11	102	41	45	417	169	79	733	296	
12	111	45	46	426	172	80	742	300	
13	120	49	47	436	176	81	751	304	
14	130	52	48	445	180	82	760	307	
15	139	56	49	454	184	83	770	311	
16	148	60	50	464	187	84	779	315	
17	157	64	51	473	191	85	788	319	
18	167	67	52	482	195	86	797	322	
19	175	71	53	491	199	87	806	326	
20	185	75	54	501	202	88	816	330	
21	195	79	55	510	206	89	825	334	
22	204	82	56	519	210	90	834	337	
23	213	86	57	529	214	91	844	341	
24	222	90	58	538	217	92	853	345	
25	232	94	59	547	221	93	862	349	
26	241	97	60	556	225	94	871	352	
27	250	101	61	566	229	95	881	356	
28	260	105	62	575	232	96	890	360	
29	269	109	63	584	236	97	899	364	
30	278	112	64	594	240	98	909	367	
31	287	116	65	603	244	99	918	371	
32	297	120	66	613	247	100	927	375	
33	306	124	67	623	251				
34	315	127	68	631	255				
						300	2782	1094	

M	23 d.	67 d.	M	23 d.	67 d.	Min.	23 d.	67 d.
1	9	4	35	322	137	69	635	269
2	18	8	36	331	141	70	644	273
3	28	12	37	340	144	71	653	277
4	37	16	38	350	148	72	663	281
5	46	19	39	359	152	73	672	285
6	55	23	40	368	156	74	681	289
7	64	27	41	377	160	75	690	293
8	74	31	42	386	164	76	699	297
9	83	35	43	396	168	77	709	301
10	92	39	44	405	172	78	718	305
11	101	43	45	414	176	79	727	308
12	110	47	46	423	180	80	736	312
13	120	51	47	433	184	81	746	316
14	129	55	48	442	187	82	755	320
15	138	59	49	451	191	83	764	324
16	147	62	50	460	195	84	773	328
17	156	66	51	469	199	85	782	332
18	166	70	52	479	203	86	792	336
19	175	74	53	488	207	87	801	340
20	184	78	54	497	211	88	810	344
21	193	82	55	506	215	89	819	348
22	202	86	56	515	219	90	828	352
23	212	90	57	524	223	91	838	356
24	221	94	58	534	226	92	847	360
25	230	98	59	543	230	93	856	363
26	239	102	60	552	234	94	865	367
27	248	105	61	561	238	95	874	370
28	258	109	62	571	242	96	884	375
29	267	113	63	580	246	97	893	379
30	276	117	64	589	250	98	902	383
31	285	121	65	598	254	99	911	387
32	294	125	66	608	258	100	920	391
33	304	129	67	618	262	200	1841	781
34	313	133	68	626	266	300	2761	1172

M	24 d	66 d	M	24 d	66 d	Min.	24 d	66 d
1	9	4	35	320	142	69	630	281
2	18	8	36	329	146	70	639	285
3	27	12	37	338	151	71	648	289
4	36	15	38	347	155	72	657	293
5	46	20	39	356	159	73	667	297
6	55	24	40	365	163	74	676	301
7	64	28	41	374	167	75	685	305
8	73	32	42	384	171	76	694	309
9	82	37	43	393	175	77	703	313
10	91	41	44	402	179	78	712	317
11	100	45	45	411	183	79	721	321
12	109	49	46	420	187	80	731	325
13	119	53	47	429	191	81	740	329
14	128	57	48	438	195	82	749	333
15	137	61	49	448	199	83	758	337
16	146	65	50	457	203	84	767	341
17	155	69	51	466	207	85	776	345
18	164	73	52	475	211	86	785	349
19	173	77	53	484	216	87	795	353
20	183	81	54	493	220	88	804	357
21	192	85	55	502	224	89	813	362
22	201	90	56	511	228	90	822	366
23	210	94	57	521	232	91	831	370
24	219	98	58	530	236	92	840	374
25	228	102	59	539	240	93	849	378
26	237	106	60	548	244	94	858	382
27	246	110	61	557	248	95	868	386
28	256	113	62	566	252	96	877	390
29	265	117	63	575	256	97	886	395
30	274	122	64	585	260	98	895	399
31	283	126	65	594	264	99	904	403
32	292	130	66	603	268	100	913	407
33	301	134	67	612	272	200	1827	813
34	310	138	68	621	276	300	2740	1220

M	25 d.	65 d.	M	25 d.	65 d.	Min.	25 d.	65 d.
1	9	4	35	317	148	69	626	292
2	18	8	36	326	152	70	634	296
3	27	13	37	335	156	71	643	300
4	36	17	38	344	161	72	652	305
5	45	21	39	353	165	73	662	309
6	54	25	40	362	169	74	671	313
7	63	30	41	372	173	75	680	317
8	72	34	42	381	178	76	689	321
9	81	38	43	390	182	77	698	326
10	91	42	44	399	186	78	707	330
11	100	47	45	408	190	79	716	334
12	109	51	46	417	195	80	725	338
13	118	55	47	426	199	81	734	343
14	127	59	48	435	203	82	743	347
15	136	63	49	444	207	83	752	351
16	145	68	50	453	211	84	761	355
17	154	72	51	462	216	85	770	360
18	163	76	52	471	220	86	779	364
19	172	80	53	480	224	87	788	368
20	181	84	54	489	228	88	797	372
21	190	89	55	498	232	89	807	376
22	199	93	56	507	237	90	816	380
23	208	97	57	516	241	91	825	384
24	218	101	58	526	245	92	834	389
25	227	106	59	535	250	93	843	393
26	236	110	60	544	254	94	852	397
27	245	114	61	553	258	95	861	401
28	254	118	62	562	262	96	870	406
29	263	123	63	571	267	97	879	410
30	272	127	64	580	271	98	888	414
31	281	151	65	589	275	99	897	418
32	290	135	66	598	279	100	906	423
33	299	140	67	607	283	200	1813	845
34	308	144	68	616	288	300	2719	1268

M	26d	64 d.	M	26 d	64d.	Min.	26 d.	64 d.
1	9	4	55	315	153	69	620	302
2	18	9	56	324	158	70	629	307
3	27	13	57	333	162	71	638	311
4	36	18	58	342	166	72	647	316
5	45	22	59	351	171	73	656	320
6	54	26	60	360	175	74	665	324
7	63	31	61	368	179	75	674	329
8	72	35	62	378	184	76	683	333
9	81	39	63	386	188	77	692	338
10	90	44	64	395	193	78	701	342
11	99	48	65	404	197	79	710	346
12	108	53	66	413	202	80	719	351
13	117	57	67	422	206	81	728	355
14	126	61	68	431	210	82	737	359
15	135	66	69	440	214	83	746	364
16	144	70	70	449	219	84	755	368
17	153	74	71	458	223	85	764	372
18	162	79	72	467	228	86	773	377
19	171	83	73	476	232	87	782	381
20	180	88	74	485	237	88	791	385
21	189	92	75	494	241	89	800	390
22	198	96	76	503	245	90	809	394
23	207	101	77	512	250	91	818	399
24	216	105	78	521	254	92	827	403
25	225	109	79	530	258	93	836	407
26	234	114	80	539	263	94	845	412
27	243	118	81	548	267	95	854	416
28	252	123	82	557	272	96	863	421
29	261	127	83	566	276	97	872	425
30	270	131	84	575	280	98	881	429
31	279	136	85	584	285	99	890	434
32	288	140	86	593	289	100	899	438
33	297	144	87	602	294	200	1798	877
34	306	149	88	611	298	300	2695	1315

The Sea-man's Practice.

M	27 d	63 d	M	27 d	63 d	Min.	27 d	63 d
1	9	5	35	312	159	69	615	313
2	18	9	36	321	163	70	624	318
3	27	14	37	330	168	71	633	322
4	36	18	38	338	172	72	641	327
5	45	23	39	347	177	73	650	332
6	53	27	40	356	182	74	659	336
7	62	32	41	365	186	75	668	341
8	71	36	42	374	191	76	677	345
9	80	41	43	383	195	77	686	350
10	89	45	44	391	200	78	695	354
11	98	50	45	401	204	79	704	359
12	107	54	46	410	209	80	713	363
13	116	59	47	419	213	81	722	368
14	125	63	48	428	218	82	731	372
15	134	68	49	435	222	83	739	377
16	143	72	50	445	227	84	748	381
17	151	77	51	454	232	85	757	386
18	160	82	52	463	236	86	766	390
19	169	86	53	472	241	87	775	395
20	178	91	54	481	245	88	784	400
21	187	95	55	490	250	89	793	404
22	196	100	56	499	254	90	802	409
23	205	104	57	508	259	91	811	413
24	214	109	58	517	263	92	820	418
25	223	113	59	526	268	93	829	422
26	232	118	60	535	272	94	837	427
27	241	122	61	543	277	95	846	431
28	249	127	62	552	282	96	855	436
29	258	132	63	561	286	97	864	440
30	267	136	64	570	291	98	873	445
31	276	141	65	579	295	99	882	449
32	285	145	66	588	300	100	891	454
33	294	150	67	597	304	200	1782	909
34	303	154	68	606	309	300	2673	1363

M	28 d	62 d.	M	28 d	62 d.	Min.	28 d.	62 d.
1	9	5	35	309	164	69	609	324
2	18	9	36	318	169	70	618	329
3	26	14	37	326	174	71	627	333
4	35	19	38	335	178	72	636	338
5	44	23	39	344	183	73	644	343
6	53	28	40	353	188	74	653	347
7	62	33	41	362	192	75	662	352
8	71	37	42	371	197	76	671	357
9	79	42	43	380	202	77	680	361
10	88	47	44	388	207	78	689	366
11	97	52	45	397	211	79	679	371
12	106	56	46	406	216	80	706	376
13	115	61	47	415	221	81	715	380
14	124	66	48	424	225	82	724	385
15	132	70	49	432	230	83	733	390
16	141	75	50	441	235	84	742	394
17	150	80	51	450	239	85	750	399
18	159	84	52	459	244	86	759	404
19	168	89	53	468	249	87	768	408
20	177	94	54	477	254	88	777	413
21	185	99	55	485	258	89	786	418
22	194	103	56	494	263	90	795	422
23	203	108	57	503	268	91	803	427
24	212	113	58	512	272	92	812	432
25	221	117	59	521	277	93	821	437
26	230	122	60	530	282	94	830	441
27	238	127	61	538	286	95	839	446
28	247	131	62	547	291	96	848	451
29	256	136	63	556	295	97	856	455
30	265	141	64	565	300	98	855	460
31	274	145	65	574	305	99	874	465
32	282	150	66	583	310	100	883	409
33	291	155	67	591	315	200	1756	939
34	300	160	68	600	319	300	2649	1408

M	29d	61 d.	M	29d	61d.	Min.	29 d.	61 d.
1	9	5	35	306	170	69	604	334
2	17	10	36	315	174	70	612	339
3	26	14	37	324	179	71	621	344
4	35	19	38	332	184	72	630	349
5	44	24	39	341	189	73	638	354
6	52	29	40	350	194	74	647	359
7	61	34	41	359	199	75	656	363
8	70	39	42	367	203	76	665	368
9	79	43	43	376	208	77	673	373
10	87	48	44	385	213	78	682	378
11	96	53	45	394	218	79	691	383
12	105	58	46	402	223	80	700	388
13	114	63	47	411	228	81	708	393
14	122	68	48	420	233	82	717	397
15	131	73	49	429	237	83	726	402
16	140	77	50	437	242	84	735	407
17	149	82	51	445	247	85	743	412
18	157	87	52	455	252	86	752	417
19	166	92	53	464	257	87	761	422
20	175	97	54	472	262	88	770	427
21	184	102	55	481	267	89	778	431
22	192	107	56	490	271	90	787	436
23	201	111	57	499	276	91	796	441
24	210	116	58	507	281	92	805	446
25	219	121	59	516	286	93	813	451
26	227	126	60	525	291	94	822	456
27	236	131	61	534	296	95	831	461
28	245	136	62	542	301	96	840	465
29	254	141	63	551	305	97	848	470
30	262	145	64	560	310	98	857	475
31	271	150	65	569	315	99	856	480
32	280	155	66	577	320	100	875	485
33	289	160	67	586	325	200	1749	970
34	297	165	68	595	330	300	2624	1454

30

M	30 d	60 d	M	30 d	60 d	Min.	30 d	60 d
1	9	5	35	303	175	69	598	345
2	17	10	36	312	180	70	606	350
3	26	15	37	320	185	71	615	355
4	35	20	38	329	190	72	623	360
5	43	25	39	338	195	73	632	365
6	52	30	40	346	200	74	641	370
7	61	35	41	355	205	75	649	375
8	69	40	42	364	210	76	658	380
9	78	45	43	372	215	77	667	385
10	87	50	44	381	220	78	676	390
11	95	55	45	390	225	79	684	395
12	104	60	46	398	230	80	693	400
13	113	65	47	407	235	81	702	405
14	121	70	48	416	240	82	710	410
15	130	75	49	424	245	83	719	415
16	139	80	50	433	250	84	727	420
17	147	85	51	442	255	85	736	425
18	156	90	52	450	260	86	745	430
19	165	95	53	459	265	87	753	435
20	173	100	54	468	270	88	762	440
21	182	105	55	476	275	89	771	445
22	191	110	56	485	280	90	779	450
23	199	115	57	494	285	91	788	455
24	208	120	58	502	290	92	797	460
25	217	125	59	511	295	93	806	465
26	225	130	60	520	300	94	814	470
27	234	135	61	528	305	95	823	475
28	242	140	62	537	310	96	832	480
29	251	145	63	546	315	97	840	485
30	260	150	64	554	320	98	849	490
31	258	155	65	563	325	99	857	495
32	277	160	66	572	330	100	866	500
33	286	155	67	580	335	200	1732	1000
34	294	170	68	589	340	300	2598	1500

M	312	59 d.	M	312	59 d.	M	Min.	31	59 d.
1	9	5	35	300	180	69	591	355	
2	17	10	36	309	185	70	600	360	
3	26	15	37	317	191	71	609	366	
4	34	21	38	326	196	72	617	371	
5	43	26	39	334	201	73	626	376	
6	51	31	40	343	206	74	634	381	
7	60	36	41	351	211	75	643	386	
8	69	41	42	360	216	76	651	391	
9	77	46	43	369	221	77	660	397	
10	86	51	44	377	227	78	669	402	
11	94	57	45	386	232	79	677	407	
12	103	62	46	394	237	80	686	412	
13	111	67	47	403	242	81	694	417	
14	120	72	48	411	247	82	703	422	
15	129	77	49	420	252	83	711	427	
16	137	82	50	429	257	84	720	433	
17	146	88	51	437	263	85	729	438	
18	154	93	52	446	268	86	737	443	
19	163	98	53	454	273	87	746	448	
20	171	103	54	463	278	88	754	453	
21	180	108	55	471	283	89	763	458	
22	189	113	56	480	288	90	771	463	
23	197	118	57	489	294	91	780	469	
24	206	124	58	497	299	92	789	474	
25	214	129	59	506	304	93	797	479	
26	223	134	60	514	309	94	806	484	
27	231	139	61	523	314	95	814	489	
28	240	144	62	531	319	96	823	494	
29	249	149	63	540	324	97	831	500	
30	257	154	64	549	330	98	840	505	
31	266	160	65	557	335	99	849	510	
32	274	165	66	566	340	100	857	515	
33	283	170	67	574	345	200	1714	1030	
34	292	175	68	583	350	300	2572	1545	

M	32 d	58 d	M	32 d	58 d	Min.	32 d	58 d
1	8	5	35	297	185	69	585	366
2	17	11	36	305	191	70	594	371
3	25	16	37	314	196	71	602	376
4	34	21	38	322	201	72	610	381
5	42	25	39	331	207	73	619	387
6	51	32	40	339	212	74	627	392
7	59	37	41	348	217	75	636	397
8	68	42	42	356	223	76	644	403
9	76	48	43	365	228	77	653	408
10	85	52	44	373	233	78	661	413
11	93	58	45	382	238	79	670	419
12	101	64	46	390	244	80	678	424
13	110	69	47	398	249	81	687	426
14	119	74	48	407	254	82	695	434
15	127	79	49	415	260	83	703	440
16	136	85	50	424	265	84	712	445
17	144	90	51	432	270	85	721	450
18	153	95	52	441	275	86	729	456
19	161	101	53	449	281	87	738	461
20	170	106	54	458	286	88	746	466
21	178	111	55	466	291	89	755	472
22	187	117	56	475	297	90	763	477
23	195	122	57	483	302	91	772	482
24	204	127	58	492	307	92	780	487
25	212	132	59	500	313	93	788	493
26	220	138	60	509	318	94	797	498
27	229	143	61	517	323	95	805	503
28	237	148	62	526	329	96	814	509
29	245	153	63	534	334	97	822	514
30	254	159	64	543	339	98	831	519
31	263	164	65	552	344	99	839	524
32	271	170	66	560	350	100	848	530
33	280	175	67	568	355	200	1696	1090
34	288	180	68	577	360	300	2544	1590

M	33d	57 d.	M	33d	57d.	Min.	33 d.	57 d.
1	8	5	35	294	191	69	579	376
2	17	11	36	302	196	70	587	381
3	25	16	37	311	202	71	596	386
4	34	22	38	319	207	72	604	392
5	42	27	39	327	212	73	612	397
6	50	33	40	335	218	74	621	403
7	59	38	41	344	223	75	629	408
8	67	44	42	352	229	76	637	414
9	76	49	43	361	234	77	646	419
10	84	54	44	369	240	78	654	425
11	92	60	45	377	245	79	663	430
12	101	65	46	386	251	80	671	436
13	109	71	47	394	256	81	679	441
14	117	76	48	403	262	82	688	446
15	126	82	49	411	267	83	696	452
16	134	87	50	419	272	84	705	457
17	143	93	51	428	278	85	713	462
18	151	98	52	436	283	86	721	468
19	159	104	53	445	288	87	730	473
20	168	109	54	453	294	88	738	479
21	176	114	55	461	300	89	747	484
22	185	120	56	470	305	90	755	490
23	193	125	57	478	310	91	763	495
24	201	131	58	487	316	92	772	501
25	210	136	59	495	321	93	780	506
26	218	142	60	503	327	94	789	512
27	227	147	61	512	332	95	797	517
28	235	153	62	520	338	96	805	522
29	243	158	63	529	343	97	814	528
30	252	163	64	537	348	98	822	533
31	260	169	65	545	354	99	831	539
32	269	174	66	554	355	100	839	545
33	277	180	67	562	365	200	1677	1089
34	285	185	68	571	370	300	2516	1634

M	34 ^d	56 ^d	M	34 ^d	56 ^d	Min.	34 ^d	56 ^d
1	8	6	35	290	196	69	572	386
2	17	11	36	298	201	70	580	391
3	25	17	37	307	207	71	588	397
4	33	22	38	315	212	72	597	403
5	41	28	39	323	218	73	605	408
6	50	34	40	332	224	74	613	414
7	58	39	41	340	229	75	622	419
8	66	45	42	348	235	76	630	425
9	75	50	43	356	240	77	638	431
10	83	56	44	365	246	78	647	436
11	91	61	45	373	251	79	655	442
12	99	67	46	381	257	80	663	447
13	108	73	47	390	263	81	671	453
14	116	78	48	498	268	82	680	458
15	124	84	49	406	274	83	688	464
16	133	89	50	414	280	84	696	470
17	141	95	51	423	285	85	705	475
18	149	101	52	431	291	86	713	481
19	158	106	53	439	296	87	721	486
20	166	112	54	448	302	88	720	492
21	174	117	55	456	307	89	730	498
22	182	123	56	464	313	90	746	503
23	191	129	57	473	319	91	754	509
24	199	134	58	481	324	92	763	514
25	207	140	59	489	330	93	771	520
26	216	145	60	497	335	94	779	526
27	224	151	61	506	341	95	788	531
28	232	157	62	514	346	96	796	537
29	240	162	63	522	352	97	804	542
30	249	168	64	530	358	98	812	548
31	257	173	65	539	363	99	821	554
32	265	179	66	547	369	100	829	559
33	274	184	67	555	374	200	1658	1118
34	282	190	68	564	380	300	2487	1678

M	35 d	55 d	M	35 d	55 d	Min.	35 d	55 d
1	8	6	35	286	201	69	565	396
2	17	11	36	299	206	70	573	403
3	25	17	37	309	212	71	582	407
4	33	23	38	311	211	72	590	413
5	41	29	39	319	214	73	598	419
6	49	34	40	328	222	74	606	425
7	57	40	41	336	235	75	615	430
8	66	46	42	344	241	76	623	436
9	74	52	43	352	246	77	631	442
10	82	57	44	360	252	78	639	448
11	90	63	45	368	258	79	647	453
12	98	69	46	377	264	80	655	459
13	106	75	47	385	270	81	664	465
14	115	80	48	393	275	82	672	470
15	123	86	49	401	281	83	680	476
16	131	92	50	410	287	84	688	482
17	139	98	51	418	291	85	696	488
18	147	103	52	426	298	86	705	493
19	156	109	53	434	304	87	713	499
20	164	115	54	442	310	88	721	505
21	172	120	55	450	315	89	729	511
22	180	126	56	459	320	90	737	516
23	188	132	57	467	327	91	746	522
24	196	138	58	475	334	92	754	528
25	205	143	59	483	338	93	762	534
26	213	149	60	491	344	94	770	539
27	221	155	61	500	350	95	778	545
28	229	161	62	508	356	96	786	551
29	237	166	63	516	361	97	795	556
30	246	172	64	524	367	98	803	562
31	254	178	65	533	373	99	811	568
32	262	184	66	541	379	100	819	574
33	270	189	67	549	384	200	838	7147
34	278	195	68	557	390	300	2458	1721

M.	36 d.	54 d.	M.	36 d.	54 d.	Min.	36 d.	54 d.
1	8	8	35	283	206	69	558	400
2	16	12	36	291	211	70	566	411
3	24	18	37	299	217	71	574	417
4	32	23	38	307	223	72	582	423
5	40	29	39	315	229	73	590	429
6	48	35	40	324	235	74	599	435
7	57	41	41	332	241	75	607	441
8	65	47	42	340	247	76	615	447
9	72	53	43	348	253	77	623	453
10	81	59	44	356	258	78	631	458
11	89	65	45	364	264	79	639	464
12	97	70	46	372	270	80	647	470
13	105	76	47	380	276	81	655	476
14	113	82	48	388	282	82	663	482
15	121	88	49	396	288	83	671	488
16	129	94	50	404	294	84	680	494
17	138	100	51	413	300	85	688	500
18	146	106	52	421	306	86	696	506
19	154	112	53	429	311	87	704	511
20	162	118	54	437	317	88	712	517
21	170	123	55	445	323	89	720	523
22	178	129	56	453	329	90	728	529
23	186	135	57	461	335	91	736	535
24	194	141	58	469	341	92	744	541
25	202	147	59	477	347	93	752	547
26	210	153	60	485	353	94	760	553
27	218	159	61	493	358	95	768	558
28	226	164	62	502	364	96	777	564
29	235	170	63	510	370	97	785	570
30	243	176	64	518	376	98	793	575
31	251	182	65	526	382	99	801	582
32	259	188	66	534	388	100	809	588
33	267	194	67	542	394	200	1618	1176
34	275	200	68	550	400	300	2427	1763

M	37 d	53 d	M	37 d	53 d	Min.	37 d	53 d
1	8	6	35	279	210	69	551	415
2	16	12	36	287	216	70	559	421
3	24	18	37	295	222	71	567	427
4	32	24	38	303	228	72	575	433
5	40	30	39	311	234	73	583	439
6	48	36	40	319	241	74	591	445
7	56	42	41	327	247	75	599	451
8	64	48	42	335	253	76	607	457
9	72	54	43	343	259	77	615	463
10	80	60	44	351	265	78	623	469
11	88	66	45	359	271	79	631	475
12	96	72	46	367	277	80	639	481
13	104	78	47	375	283	81	647	487
14	112	84	48	383	289	82	655	493
15	120	90	49	391	295	83	663	500
16	128	96	50	399	301	84	671	506
17	136	102	51	407	307	85	679	512
18	144	108	52	415	313	86	687	518
19	152	114	53	423	319	87	695	524
20	160	120	54	431	325	88	703	530
21	168	126	55	439	331	89	711	536
22	176	132	56	447	337	90	719	542
23	184	138	57	455	343	91	727	548
24	192	144	58	463	349	92	735	554
25	200	150	59	471	355	93	743	550
26	208	156	60	479	361	94	751	556
27	216	162	61	487	367	95	759	572
28	224	168	62	495	373	96	767	578
29	232	174	63	503	379	97	775	584
30	240	180	64	511	385	98	783	590
31	248	186	65	519	392	99	791	596
32	256	192	66	527	397	100	799	602
33	264	198	67	535	403	200	1597	1204
34	272	204	68	543	409	300	2396	1805

M	38 d	52 d	M	38 d	52 d	Min.	38 d	52 d
1	8	6	35	276	216	69	544	425
2	16	12	36	284	222	70	552	431
3	24	18	37	292	228	71	559	437
4	31	25	38	299	234	72	567	443
5	39	31	39	307	240	73	575	450
6	47	37	40	315	246	74	583	456
7	55	43	41	323	252	75	591	462
8	63	49	42	331	259	76	599	468
9	71	55	43	339	265	77	607	474
10	79	62	44	347	271	78	615	480
11	87	68	45	355	277	79	622	486
12	95	74	46	362	283	80	630	493
13	102	80	47	370	289	81	638	499
14	110	86	48	378	295	82	646	505
15	118	92	49	386	302	83	654	511
16	126	99	50	394	308	84	662	517
17	134	105	51	402	314	85	670	523
18	142	111	52	410	320	86	678	530
19	150	117	53	418	326	87	686	536
20	158	123	54	426	332	88	693	542
21	166	129	55	433	339	89	701	548
22	173	136	56	441	345	90	709	554
23	181	142	57	449	351	91	717	550
24	189	148	58	457	357	92	725	556
25	197	154	59	465	363	93	733	573
26	205	160	60	473	369	94	748	579
27	213	166	61	481	376	95	749	585
28	221	172	62	489	382	96	756	591
29	229	179	63	496	388	97	764	597
30	236	185	64	504	394	98	772	603
31	244	191	65	512	400	99	780	610
32	252	197	66	520	406	100	788	616
33	260	203	67	528	412	200	1576	1231
34	268	209	68	536	419	300	2364	1847

M	39 d	51 d	M	39 d	51 d	Min.	39 d	51 d
1	8	6	35	272	220	69	536	434
2	16	13	36	280	226	70	544	440
3	23	19	37	287	233	71	552	447
4	31	25	38	295	239	72	559	453
5	39	31	39	303	245	73	567	459
6	47	38	40	311	252	74	575	466
7	54	44	41	318	258	75	583	472
8	62	50	42	326	264	76	591	478
9	70	57	43	334	271	77	598	485
10	78	63	44	342	277	78	606	491
11	85	69	45	350	283	79	614	497
12	93	75	46	357	289	80	622	503
13	101	82	47	365	295	81	629	510
14	109	88	48	373	302	82	637	516
15	116	94	49	381	308	83	645	522
16	124	101	50	388	315	84	653	529
17	132	107	51	396	321	85	661	535
18	140	113	52	404	327	86	668	541
19	148	119	53	412	334	87	676	547
20	155	126	54	419	340	88	684	554
21	163	132	55	427	346	89	692	560
22	171	138	56	435	352	90	699	566
23	179	145	57	443	359	91	707	573
24	186	151	58	451	365	92	715	579
25	194	157	59	458	371	93	723	585
26	202	164	60	466	378	94	731	591
27	210	170	61	474	384	95	738	598
28	217	176	62	482	390	96	746	604
29	225	182	63	489	396	97	754	610
30	233	189	64	497	403	98	762	617
31	241	195	65	505	409	99	769	623
32	249	201	66	513	415	100	777	629
33	256	208	67	521	422	200	1554	1259
34	264	214	68	528	428	300	2331	1888

M	40 d.	50 d.	M	40 d.	50 d.	Min.	40 d.	50 d.
1	8	6	35	268	225	69	529	443
2	15	13	36	276	231	70	536	450
3	23	19	37	283	238	71	544	456
4	31	26	38	291	244	72	552	463
5	38	32	39	299	251	73	559	469
6	46	38	40	306	257	74	567	476
7	54	45	41	314	263	75	574	482
8	61	51	42	322	270	76	582	485
9	69	58	43	329	276	77	590	495
10	77	64	44	337	283	78	597	501
11	84	71	45	345	289	79	605	508
12	92	77	46	352	296	80	613	514
13	100	83	47	360	302	81	620	521
14	107	90	48	368	309	82	628	527
15	115	96	49	375	315	83	636	533
16	123	103	50	383	321	84	643	540
17	130	109	51	391	328	85	651	546
18	138	116	52	398	334	86	659	553
19	146	122	53	406	341	87	666	559
20	153	129	54	414	347	88	674	566
21	161	135	55	421	353	89	682	572
22	169	141	56	429	360	90	689	579
23	176	148	57	437	366	91	697	585
24	184	154	58	444	373	92	705	591
25	192	161	59	452	379	93	712	598
26	199	167	60	460	386	94	720	604
27	207	173	61	467	392	95	727	611
28	214	180	62	475	399	96	735	617
29	222	186	63	483	405	97	743	623
30	230	193	64	490	411	98	751	630
31	237	199	65	498	418	99	758	636
32	245	206	66	506	424	100	766	643
33	253	212	67	513	431	200	1532	1286
34	260	219	68	521	437	300	2298	1928

M	41 d	49 d	M	41 d	49 d	Min.	41 d	49 d
1	8	7	35	264	229	69	521	452
2	15	13	36	272	236	70	528	459
3	23	20	37	279	243	71	536	466
4	30	26	38	287	249	72	543	472
5	38	33	39	294	256	73	551	478
6	45	39	40	302	262	74	558	485
7	53	46	41	309	269	75	566	492
8	60	52	42	317	275	76	574	498
9	68	59	43	324	282	77	581	505
10	75	66	44	332	289	78	589	512
11	83	72	45	339	295	79	596	518
12	91	79	46	347	302	80	604	525
13	98	85	47	354	308	81	611	531
14	106	92	48	362	315	82	619	538
15	113	98	49	369	321	83	626	544
16	121	105	50	377	328	84	634	551
17	128	112	51	385	334	85	641	557
18	136	118	52	392	341	86	649	564
19	143	125	53	400	348	87	656	571
20	151	131	54	407	354	88	664	577
21	159	138	55	415	361	89	671	584
22	166	144	56	422	367	90	679	590
23	174	151	57	430	374	91	687	597
24	181	157	58	438	380	92	694	603
25	189	164	59	445	387	93	702	610
26	196	171	60	453	394	94	709	616
27	204	177	61	460	400	95	717	623
28	211	184	62	468	407	96	724	629
29	219	190	63	475	413	97	732	636
30	226	197	64	483	420	98	739	643
31	234	203	65	490	426	99	747	649
32	241	210	66	498	433	100	755	656
33	249	216	67	506	439	200	1509	1312
34	257	223	68	513	446	300	2264	1968

M	42 d	48 d	M	42 d	48 d	Min.	42 d	48 d
1	7	7	35	250	234	69	513	462
2	15	13	36	267	241	70	520	468
3	22	20	37	275	247	71	527	475
4	30	27	38	282	254	72	535	482
5	37	33	39	290	261	73	542	488
6	44	40	40	297	268	74	550	491
7	52	47	41	304	274	75	557	505
8	59	53	42	312	281	76	564	509
9	67	60	43	319	287	77	572	515
10	74	67	44	327	294	78	579	522
11	82	73	45	334	301	79	587	529
12	89	80	46	342	308	80	594	535
13	97	87	47	349	314	81	602	542
14	104	93	48	357	321	82	609	549
15	111	100	49	364	328	83	617	555
16	119	107	50	372	335	84	624	562
17	126	113	51	379	341	85	632	569
18	134	120	52	386	348	86	639	575
19	141	127	53	394	354	87	647	582
20	149	134	54	401	361	88	654	589
21	156	140	55	409	368	89	661	595
22	163	147	56	416	375	90	669	602
23	171	154	57	423	381	91	676	609
24	178	160	58	431	388	92	684	615
25	186	167	59	438	394	93	691	622
26	193	174	60	446	401	94	699	629
27	201	180	61	453	408	95	706	635
28	208	187	62	461	415	96	713	642
29	215	194	63	468	421	97	721	649
30	223	201	64	475	428	98	728	655
31	230	207	65	483	435	99	736	662
32	238	214	66	490	442	100	743	669
33	245	221	67	498	448	200	1486	1338
34	253	227	68	505	455	300	2229	2007

M	43 d	47 d	M	43 d	47 d	Min.	43 d	47 d
1	7	7	35	255	239	69	505	470
2	15	14	36	263	245	70	512	477
3	22	20	37	270	252	71	519	484
4	29	27	38	278	259	72	526	491
5	36	34	39	285	266	73	534	498
6	44	41	40	292	273	74	541	505
7	51	48	41	300	280	75	548	511
8	58	54	42	307	286	76	556	518
9	66	61	43	314	293	77	563	525
10	73	68	44	322	300	78	570	532
11	80	75	45	329	307	79	578	539
12	88	82	46	336	314	80	585	546
13	95	89	47	344	320	81	592	552
14	102	95	48	351	327	82	600	559
15	110	102	49	358	334	83	607	566
16	117	109	50	366	341	84	614	573
17	124	116	51	373	348	85	622	580
18	132	123	52	380	355	86	629	587
19	139	130	53	388	361	87	636	593
20	146	136	54	395	368	88	643	600
21	153	143	55	402	375	89	651	607
22	161	150	56	409	382	90	658	614
23	168	157	57	417	389	91	665	621
24	175	164	58	424	395	92	673	627
25	183	170	59	431	402	93	680	634
26	190	177	60	439	409	94	687	641
27	197	184	61	446	416	95	695	648
28	205	191	62	453	423	96	702	655
29	212	198	63	461	430	97	709	661
30	219	205	64	468	436	98	717	668
31	227	211	65	475	443	99	724	675
32	234	218	66	483	450	100	731	682
33	241	225	67	490	457	200	1463	1364
34	248	232	68	497	464	300	2194	2046

M	44 d	46 d	M	44 d	46 d	Min.	44 d	46 d
1	7	7	35	252	243	69	496	479
2	14	14	36	259	250	70	503	486
3	22	21	37	266	257	71	511	493
4	29	28	38	273	264	72	518	500
5	36	35	39	280	271	73	525	507
6	43	42	40	288	278	74	532	514
7	50	49	41	295	285	75	539	521
8	58	56	42	302	292	76	547	528
9	65	62	43	309	299	77	554	535
10	72	69	44	316	306	78	561	542
11	79	76	45	324	313	79	568	549
12	86	83	46	331	320	80	575	556
13	93	90	47	338	327	81	583	563
14	101	97	48	345	334	82	590	570
15	108	104	49	352	340	83	597	577
16	115	111	50	360	347	84	604	584
17	122	118	51	367	354	85	611	590
18	129	125	52	374	361	86	619	497
19	137	132	53	381	368	87	626	604
20	144	139	54	388	375	88	633	611
21	151	146	55	496	382	89	640	618
22	158	153	56	403	389	90	647	625
23	165	160	57	410	396	91	655	632
24	173	167	58	417	403	92	662	639
25	180	174	59	424	410	93	669	646
26	487	181	60	432	417	94	676	653
27	194	188	61	439	424	95	683	660
28	201	195	62	446	431	96	690	667
29	209	201	63	453	438	97	798	674
30	216	208	64	460	445	98	705	681
31	223	215	65	468	452	99	712	688
32	230	222	66	475	458	100	719	695
33	237	229	67	482	465	200	1439	1389
34	145	236	68	489	472	300	2158	2084

M	45 d.	45 d.	M	45 d.	45 d.	Min.	45 d.	45 d.
1	7	7	35	247	247	69	488	488
2	14	14	36	254	254	70	495	495
3	21	21	37	261	261	71	502	502
4	28	28	38	268	268	72	509	509
5	35	35	39	275	275	73	516	516
6	42	42	40	283	283	74	523	523
7	49	49	41	290	290	75	530	530
8	56	56	42	297	297	76	537	537
9	64	64	43	304	304	77	544	544
10	71	71	44	311	311	78	551	551
11	78	78	45	318	318	79	558	558
12	85	85	46	325	325	80	566	566
13	92	92	47	332	332	81	573	573
14	99	99	48	339	339	82	580	580
15	106	106	49	346	346	83	587	587
16	113	113	50	353	353	84	594	594
17	120	120	51	360	360	85	601	601
18	127	127	52	367	367	86	608	608
19	134	134	53	375	375	87	615	615
20	141	141	54	382	382	88	622	622
21	148	148	55	389	389	89	629	629
22	155	155	56	396	396	90	636	636
23	163	163	57	403	403	91	643	643
24	170	170	58	410	410	92	650	650
25	177	177	59	417	417	93	657	657
26	184	184	60	424	424	94	665	665
27	191	191	61	431	431	95	672	672
28	198	198	62	438	438	96	678	678
29	205	205	63	445	445	97	686	686
30	212	212	64	452	452	98	693	693
31	219	219	65	459	459	99	700	700
32	226	226	66	466	466	100	707	707
33	233	233	67	474	474	200	1414	1414
34	240	240	68	481	481	300	2121	2121

Now for the form of setting down a Reckoning, although he which is accustomed to keep it in this manner, may haply by use and practice discern how to order it in a better way than I can presently prescribe or think upon, because he hath occasion often to consider it in every particular: yet in the mean time I conceive it will be fit to have a Book in *Folio*, that is, two leaves to a sheet of paper, and to keep the left side of your Book void, that you may write therein all such Occurrences as you shall think requisite. As namely, the Winds, and the Points of the Compass, upon which your ship lies, and what allowance you make for *Lee-ward* way when you sail by a wind, the number of Glasses or Hours, and how many Knots or Miles in each hour, also the Latitudes which you find by observation of the Meridian-altitude of the Stars, and what else you shall think remarkable. But before all this, the title of the Voyage in these or the like words,

*The Journal of our Voyage intended by Gods assistance from
S. I. in the latitude of 32 deg. 25 min. to the Coast
of England, &c.*

The right hand Pages, or the right side of your Book throughout, may by lines be divided into 12 Columns, as in the Example following doth appear. In the first Column may be expressed the *day*, in the second *month*; or at least once in the top of the page; likewise in the second column, being large enough, may be set down the Latitudes which you find by the Meridian altitudes of the Sun at such times as you make observation. In the third column the course (the *Lee-ward* way, if there be any seeing allowed.) In the 4. the Variation of the Needle. In the 5. (having made allowance for the Variation) set down the angle of your Rumb with the Meridian. In the 6. col. set down the distance in miles run upon that Rumb. In the 7, 8, 9, and 10 col. the Northing, or Southing, Easting, or Westing, thereto answering, as you shall find it by your Table. In the 11. your Latitudes by dead reckoning. And lastly in the 12 column you may at such times as you think fittest, set down your *Longitude* from the place from which you first departed, or the difference of Longitude from place to place.

da.	Lar. by ob- servation.	courle	Vari- ation.	Deg. frō the mirid	mi. in miles	Nor th	Sou th	East	W est	Lar. by Longi- dead R tude.
20	February	N E	8deg. by E west	ne 48d	78	522		579		33.17
21	Latitude 34 d. 25	N E	8deg. by E west	ne 48d	100	669		743		34.24
21	34 d. 25			Summe is		11911		11321		1134.24 02.38
22		ne	8deg. poi. west	ne 54d	100 56	588 329		809 453		35.56
23	Latitude 37 d. 46	ne	8deg. no. west	ne 54d	100 78	588 458		809 631		37.40
24	Latitude 39 d. 36	ne	8deg. no. west	ne 54d	100 84	588 494		809 679		39.28
				Summe is		30451		141901	II	I
				The correction by obser. is. 801				11101	II	081
24	39.36 II	I	II	I	II	31251		143001		39.36 11.36
25	February	ne	8deg. west	ne 59d	100 76	507 385		861 655		41.05
26		ne	8deg. west	ne 59d	100 80	507 412		861 686		42.37
27	Latitude 43 d. 55	ne	7deg. west	ne 60d	100 84	500 420		866 728		44.09
				Summe is		27311		146571	II	I
				Correction				11401	124511	I
27	L. 43.55			I		25911		144121	II	43.55 21.28
28	February	ne	6deg. west	ne 67d	100 51	391 199		921 469		44.54
29		ne	5deg. west	ne 68d	100 81	375 304		927 751		46.02
1	March	ne	4deg. west	ne 69d	100 66	358 237		934 616		47.02
2	L. 48.4	ne	2deg. west	ne 71d	100 78	326 254		946 737		48.00
2	L. 48.4			Summe is		24441		163011	II	48.00 36.8

da	Lat. by ob- servat.	cours.	Vari- ation.	De. fr. d. in the Mer. miles	Nor th.	South.	East	West	Lat. by dead R.	Longi- tude.
3	March	ene $\frac{1}{2}$ e	0 de. west	ne 73 d	100 52	292 152	956 497		48.44	
4		ene $\frac{1}{2}$ e	2 de. East	ne 75 d	100 68	259 176	966 557		49.28	
5	Latitude 49.58 d.	ene $\frac{1}{2}$ e	3 de. East	ne 76 d	98	237	951		49.52	
5	la. 49.58			Summe is 1116 1402 71 49.52 46.52						
5	8 Hours	n by $\frac{1}{2}$ e	4 de. East	ne 21 d	18	168	64		50.09	
6		outh by e	4 de East	se 7 d.	34		337 41		49.35	
6	16 Hours	n by east	4 de. East	ne 15 d	36	348	93		50.10	
7		se by east	4 de. East	se 32 d	20		123 158		49.58	
8	Latitude 50 d. 4'	East	4 de. East	se 86 d	96		67 958		49.51	
	The cur- renting by estima.	East nort. east.		ne 67 $\frac{1}{2}$	60	230	554		50.14	
				Summe is 1119 1868						
				Correction 100 10						
8	1.50 d. 4'				119	1868			50.04	51.43
9		east $\frac{1}{2}$ po. n	6 de East	se 89 $\frac{1}{2}$ d	70		60 700		49.58	
10		east $\frac{1}{2}$ po. n	6 de East	se 89 $\frac{1}{2}$ d	52		41 520		49.54	
10	March			Summe is 1101 1220 49.54 51.53						
	Here the Lizard bears	N by E			13					

For an example, we may frame a reckoning between the two places before-mentioned, namely from *Summer-Islands* to the *Lizard*, whose distance in their Rumb we have before supposed to be 3299 miles, as some Charts make it, and consequently their difference of Longitude 70 deg. I would not be understood as if I affirmed it to be so much, for I suppose it is less. I was there indeed about 20 years past, and surveyed it, and then kept a reckoning both outwards and homewards, but I have lost those reckonings long since, and have forgotten what they were, and in this case it matters not, for whether the supposition be neer the truth or not, it serves sufficiently to exemplifie the rule, that being the end for which it is used. But if their distance be 3299 such miles as contain only 1000 paces in a mile, the same being reckoned in such miles, as we have before-mentioned, namely, in such whereof 60 make a degree of a great Circle, which as we find contain 6120 feet in a mile; their distance will be little more then 2695 miles; and consequently, the difference of Longitude little more then $55\frac{1}{2}$ degrees.

Let us therefore suppose the difference of Longitude between those two places to be 55 degrees, and their Latitudes to be the same as before, namely, of the one 32 deg. 25 min. and of the other 50 degrees. And let the Courses, Distances, and other observations from *Summer-Islands* to the *Lizard* be such as before is shewed.

The first entrance in this Journal (which is the 20 day of *February*) is thus to be understood; namely, that from the time of setting sail (which we suppose to be the 19 of *February*) till the 20 day at noon, the Ship lies away, and makes her way good upon the Northeast and by E. point of the Compass; but the Variation being 8 deg. to the Westwards (as in the fourth column appears) the rumb upon which she hath run is from the North to the Eastwards only 48 d. as is expressed in the 5 column (it is indeed $48\frac{1}{2}$ deg. but the $\frac{1}{2}$ deg. we omit, as for the other circumstances not to be regarded) upon this rumb she runs 78 miles, as in the 6 column appears, and answerable thereto I find in the table before-going, the Northing to be $52\frac{1}{2}$ miles, and the Easting 57 $\frac{2}{3}$, as here in the seventh and ninth column is expressed by

by these numbers 512 and 579 (for the first figure towards the right hand signifieth the tenth parts of a mile, the rest miles.) Hence then the Northing being 52 miles, if that be added to the Latitude from which it is reckoned, namely 32 deg. 25 min. it makes the Latitude here to be 33 deg. 17 min. as in the 11 Column appears. In like sort, the second entrance being the 21 of February, sheweth that from the 20 day at noon to the 21, she made her way good upon North-east and by East point of the Compass, but the Variation being 8 deg. Westerly, the angle of the Rumb with the true Meridian was from the North to the Eastwards 48 deg. and so sailing 100 miles, the Northing is $69\frac{1}{2}$ miles, and the Easting $74\frac{1}{2}$ miles, so that the Latitude now is 34 deg. 24 min. and the like is to be understood of all the rest.

Touching the Longitude expressed in the last column, although a reckoning may be kept and set down without it, yet it is of very good use, and how to convert the Easting or Westing (that is, the miles expressed in the East and West columns of your Journal) into deg. and min. of Longitude; we will shew afterwards, as also how you may easily correct your course, and give the true Course or Rumb, allowing the Variation.

But first to proceed with this Journal, observing the Meridian altitude of the Sun upon the 23 and 24 of February, I find that my Latitude upon the 24 is 39 deg. 36 min. whereas by dead reckoning it is but 39 deg. 28 min. so the difference is 8 more Northerly: but being well assured of the Latitude found by Observation, I correct the dead reckoning thereby, which may be done by the Rule of Proportion, saying;

As the Summe of the North column 3125 Co. ar. 6.50515.

To the sum of the East column, 4300 3.63347

So the foresaid increase Northerly 80 1.90309

To the increase Easterly 110 2.04171

that is, 11 miles: for the first place towards the right hand is only for the tenth parts of a mile.

The same may also sufficiently be found without the Rule of Proportion, by the foregoing Table, only for looking there under the Degree upon which I have sailed, namely, under 54 deg.

deg. for 8 miles or 80 tenths of a mile, though I find not the same exactly, yet I find one which is neer it, namely 82, and against it in the next collateral column 113, which is $11\frac{1}{2}$ miles (being too much by $\frac{2}{5}$ of a mile, because the other is too much by $\frac{1}{10}$) I adde therefore in the North column of the Journal 8 miles, and the East column 11 miles; and so whereas by dead Reckoning, the Northing was but $304\frac{1}{2}$ miles, and the Easting 419 miles; now having corrected it by observation, the Northing is $312\frac{1}{2}$ miles, and the Easting 430 miles.

In like sort upon the 27 day, I should by dead reckoning be in the Latitude of 44 deg. 09 min. but by a clear and good observation I find my self in the Latitude of 43 deg. 55 min. that is, not so much Northerly by 14 min. therefore to correct it I put in the South column 14 miles, or 140 tenths, and seeing my Course was between the North and East, and that I find my self to be less to the Northwards, that is, more to the Southwards than my reckoning; therefore in probability I am also less to the Eastwards, that is, more to the Westwards, then my reckoning; But to find how much, I look in the foregoing Table for the degree upon which I have sailed, being from the North part of the Meridian to the Eastwards 60 deg. and under 60 deg. I look for 17 miles, or 140 tenths, and against it in the column adjoining I find 243, which I set down in my Journal in the West column, and so subtracting the first from the North column, the other from the East: I find that whereas by dead Reckoning I should be to the Northwards $273\frac{1}{2}$ miles, and to the Eastwards $465\frac{7}{10}$. Now having corrected it by observation, I find that from the 24 day till this time I have run more Northerly than I was by $259\frac{1}{10}$ miles, and more Easterly by $441\frac{3}{10}$ miles.

But if your Course be neer the East or West, it may suffice to correct it in Latitude only, as in the example of the 8 of *March* appears; for in that case you cannot correct the Longitude, but from some further ground.

If there be any Current, you may note it as is done in that Example following the 8 of *March*.

Now if you would set down this Reckoning upon the Plain or Common *Sea-chart*: First, if you desire to express every
dayes

dayes account, you may begin for the 20 of *February*, and make a prick in your plat that may be from the place from which you set sail to the Northwards $52\frac{1}{2}$ miles, and to the Eastwards $57\frac{2}{5}$; and so will this point be distant from the place of your setting sail 78 miles Northeast, and almost a quarter of a point Easterly: then for the 21 day you may make another prick, which may be from the form to the Northwards $66\frac{2}{3}$ miles, and to the Eastwards $74\frac{2}{3}$ miles; and so you may proceed with the rest. And thus you shall have a Prick on the Plot for every day more exactly set down then could be done after the ordinary way by Course and Distance, or Course and Latitude, especially because in lining the Plot, there are not, nor cannot conveniently be drawn any more then the 32 points of the Compass, to wit, not half points, quarters, or single Degrees.

But if you desire not to set down every days reckoning (which is not necessary to be done) you may set down every of the Summes, as they are corrected by Observation, after the self-same manner.

Or you may adde together all those summs, and so the summe total of the North column will be 1049 miles, and of the East column 2345 miles, therefore in the Meridian of the place from which you depart; you may set down to the Northwards of that place 1059 miles, which will fall in the Latitude of 49 deg. 54 min. almost, and from thence in that parallel set down directly to the Eastwards 2345 miles, and there make a prick for the place where the Ship then is the tenth of *March*, and so is all this reckoning set down at once.

If you keep reckoning according to *Mercator*, it will be requisite sometimes to sum up your reckonings past, namely, so often as you make any notable alteration in your Course; and so this reckoning or any other may be set down almost as easily on *Mercator's Chart*, the difference is, that here you must often alter your *Scale*, because the deg. of Latitude on this *Chart* are not equal, but grow greater and greater towards the Poles. Now then the distance of two places is to be measured by that part of the *Meridian*, which is intercepted between the Latitudes of those

two places; Or if both places lye in one and the same Latitude, their Distance is measured by a Degree or other lesser quantity, taken about that Latitude; namely, half above, and half beneath.

Wherefore if you would make a Prick or Traverse-point in *Mercators Chart*, answering to your reckoning for the first day, namely, untill the 20 of *February* at noon; it appears by your Journal that Prick must be to the Northwards of the place from which you departed $52\frac{1}{2}$ miles, and to the Eastward $57\frac{1}{2}$ miles.

Now instead of the *North* or *South* columns, you may more conveniently use the last column but one, shewing in what Latitude every account doth fall; and so it appears, that the Prick for the 20 of *February* must be in the Latitude of 33 deg. 17 min. Therefore in the Meridian of the *Summer-Islands* from which you departed make a prick in the Latitude of 33 deg. 17 min. and from that prick set down to the Eastwards in the same Latitude $57\frac{1}{2}$ miles, and where it ends is the Traverse-point answering to the 20 of *February*: the like may be done for the 21 day, and so for all the rest. This 58 miles may be taken in the Meridian from the Latitude of 32 deg. 22 min. to the Latitude of 33 deg. 20 min. or otherwise you may take the half of it which is 29 miles about the middle between both latitudes, and double it.

But it is sufficient to set down the sums of every two or three dayes accounts, or so often as there is any notable Difference in your Course; Thus if you would make a prick in the *Chart*, answering to the 21 of *February*, being the first summe; I see by the Journal, that it must be in the Latitude of 34 deg. 24 min. and to the Eastwards of the place from which I departed $132\frac{1}{2}$ miles, Therefore in the Meridian of the place from whence I departed, I make a prick in the Latitude of 34 deg. 24 min. and from that prick I set in the same Latitude to the Eastwards $132\frac{1}{2}$ miles, and where it ends is the Traverse point answering to the 21 of *February*, being the first sum. This 132 miles may be taken in the Meridian within, or a little without the two Latitudes, as before, namely, from 32 deg. 20 min. to 34 deg. 32 min.

In like sort, if you would make a prick for the second sum, being the 24 of *February*, it there appears that it must be in the Latitude of 39 deg. 36 min. and to the Eastwards of the Traverse

verse point last before made 430 miles; therefore in the Meridian of that Traverse point I make a prick in the Latitude of 39 deg. 36 min. and from that Prick I set to the Eastwards in the same Latitude 430 miles, and where that ends is the Traverse-point answering to the 24 day, and the like is to be understood of all the rest.

Now this 430 miles may be taken several wayes; for first, if I take one Degree about the middle of that part of the Meridian, which is intercepted between the Latitudes of the two places (as from 36 deg. 30 min. to 37 deg. 30 min.) and that degree seven times taken is 420 miles, then about the middle, namely, 37 deg. I take 10 min. more, and so I have 430 miles.

In like manner, you may take two deg. or 120 miles, to measure it thereby, which may be taken from 36 degrees to 38 deg. and the residue about 37 degrees, as before, &c.

Or you may take the half of 430 miles, namely, 215 miles, which is 3 deg. 35 min. which must be taken as before, about the middle of that part of the Meridian which is intercepted between the two Latitudes, and that doubled is 430 miles to be set to the Eastwards, as before.

And thus may this or any other Reckoning be set down without knowledge of the Longitudes, but more aptly and exactly by some Longitudes known, for then shall you have in the two last Columns the substance and principal scope of your reckoning; namely, the Latitudes and Longitudes of all places, as you sail, which may more easily and exactly be express'd upon this Chart, then the Easterly or Westerly distances; Therefore how this also may be done, we will shew, but first something touching the *Compass* and the *Variation* thereof, which ought not to be neglected in a reckoning.

Q

CHAP.

CHAP. X.

Of the Variation of the Compass, and how to rectifie a Course by the Variation known.



Amongst all the Mysteries which God hath of late years discovered to the World for the furtherance of *Navigation*, there is none more necessary, nor yet more admirable than that property of the *Needle* touched with the Load-stone, whereby in the vast Ocean where all Land-marks fail, yea even in the darkeſt nights and cloieſt weather, when neither Sun nor Stars are to be ſeen; the Mariner (as it were by a Meſſenger ſent from Heaven) is taught which way to direct his ſhip; yea, as it were accompanied with a guide towards his deſired Port.

For the Needle touched, beſides other ſtrange properties, hath this, to point out in all quarters of the World, the North and South parts of the Horizon, and ſo having a Card thereto fitted with Rumbs and Degrees, it ſheweth all Points of the Compaſs; and degrees of the Horizon.

Yet very ſeldom exactly of it ſelf, without ſome further Art and Induſtry of him that uſeth it; for though in ſome places it ſwerves not, yet in moſt parts of the World the North and South points of the Needle have ſome *Variation* from the true North and South points of the Horizon to the Eaſtwards or to the Weſtwards, which how to diſcover in kind and quantity, we have ſhewed heretofore.

It may be thought, (and ſome men otherwiſe learned before this Property was fully diſcovered, have ſaid) that this ſhould be ſome blemiſh and imperfection in a ſtone ſo precious; But it is ſo far from being an imperfection, that it makes it ſo much the more precious? Yet (as I have ſaid) not without the induſtry of him that uſeth it. He that is negligent or unſkilful to obſerve it, eſpecially in long Voyages and various Courſes, may be led into many dangers by it, becauſe he frames not his mind to the Rule, but the Rule to his mind, imagining it to be what it is not :
and

and hence I suppose, sprang that Custome of placing the *Needle* or *Wyers* a point or half point to the Eastwards of the North-point of the *Card*, thinking by this means to shun the labour of observing the Variation, which indeed they might, if the Variation were the same in all places, and at all times; but because it is not, this doth often encrease the Errour.

But he that diligently observes the Variation, finds (as I say) no prejudice in it, only it requires daily, or once in two or three days half an hours work; and this labour it doth abundantly recompence; for by this means he knows at the present how to direct his Course, and for the future, by those notes which he keeps of the *Variations* and *Latitudes* by him observed, he knows (coming that way again) when he draws neer to any of those places where such Observations were made, and so falls the more certainly with any place intended.

There is further discovered of late a motion or alteration in the Variation of the *Needle*, and this is scarce yet certainly discovered. But comparing the Variations which were observed about fifty years past, with the present Variations: It appears they are lesser Easterly, and more Westerly by 6 or 7 degrees, than they were at that time. For whereas the Variation hath formerly been observed neer *London* to be $11\frac{1}{2}$ Deg. to the Eastwards, it doth now scarce exceed 4 Degrees. And there is the like alteration (as I have heard by some Mariners) in other parts of the World; which we now leave to the further discovery of time and industry, and come to shew how to rectifie a Course by the Variation known.

The point of the Compass upon which you sail, and the Variation of the Needle known, to find the Rumb or Degree upon which the Ship hath made her way.

IT is best that the *Needle* or *Wyers* be placed directly under the *Flower de luce*, or North and South points of the *Card*, and so in the Rules following we presuppose them to be. Now then it is to be understood, that the *Needle* having Variation

(as for the most part it hath) the ship doth not make her way upon that Rumb or Point of the Compass, which she seems to sail upon, but either more to the right hand or to the left, according as the Variation is towards the right hand, or towards the left, and that so much towards the one side, or towards the other as that Variation is: We speak not here of *Leeward-way*, but of the Variation only. Therefore for the solution of this *Probleme* you must know how much the Variation is, and which way; And how this may be done, we have briefly shewed upon the 12 Case of *Right angled spherical Triangles*, and the 11 of *Oblique*, which known, you may find the angle of the Rumb or Line of your ships way with the *Meridian*: being the thing in this *Probleme* required.

A Table of the Angles of every Point and half Point of the Compass with the Meridian.

	North	South	D. M.	North	South
$\frac{1}{2}$			00 00		
1	N by E	S by W	05 37	N by W	S by E
$1\frac{1}{2}$			11 15		
2	NNE	SSW	16 52	NNW	SSE
$2\frac{1}{2}$			22 30		
3	NE by N	SW by S	28 07	NW by N	SE by S
$3\frac{1}{2}$			33 45		
4	NE	SW	39 22	NW	SE
$4\frac{1}{2}$			45 00		
5	NE by E	SW by W	50 37	NW by W	SE by E
$5\frac{1}{2}$			56 15		
6	ENE	WSW	61 52	WNW	ESE
$6\frac{1}{2}$			67 30		
7	E by N	W by S	73 07	W by N	E by S
$7\frac{1}{2}$			78 45		
8	East	West	84 22	West	East
			90 00		
	Add East Variation			Add West Variation	
	Subtract West.			Subtract East.	

For

For the effecting whereof, we will set down two ways; the one by the Pen alone, the other instrumentally. If you do it by the Pen alone, although it be not hard to find what angle every point or half point makes with the Meridian; yet for your further ease herein, I have expressed the same in the Table before-going; the Quarters of Points I have omitted, because the steerage upon a quarter of a point is very uncertain, (the points being undivided as usually they are) for a man by his eye is able to guess very neerly which the middle between two points, but he cannot guess so neerly which is the fourth part. Yet if you desire any quarter, you may add to the next before-going almost 3 deg. namely 2 deg. 49 min.

Now then by the Magnetical Rumb or Point of the Compass and Variation given, to find the true Rumb, you are to observe these two Rules following.

1. *If the Rumb and the Variation be both the same way from the Meridian (namely, both to the right hand, or both to the left) add them together, and that sum is the true Rumb from that part of the Meridian.*

Yet if that summe exceed 90 degrees, subtract it from 180 degrees, the remainder is the Rumb from the opposite part of the Meridian.

2. *If the one be towards the right hand, the other towards the left, subtract the Variation from the Rumb, and the remainder is the true Rumb.*

Yet if the Rumb be the smaller number, subtract it from the Variation, and the remainder is the true Rumb the other way.

These Rules we shall endeavour to illustrate by examples following.

But first, for distinction-sake we say the Rumbs or degrees from the North towards the East, are towards the right hand, and so from the South towards the West; but from the North to the Westwards, on the left hand, and so from the South Eastwards: For a mans face being towards the North, the East is on his right hand and the West on his left, &c.

In like sort for the *Variation of the Compass*, if it have Easterly variation, that is, if the *Needle and Flower de Luce* of the Card stand

stand to the Eastwards of the North, we say that *Variation* is towards the right hand, for not only the North point but all the other points of the *Compass* direct a Course more towards the right hand than they would do, if there were no *Variation*. And so if it have *Westerly Variation*; that is, if the *Needle* and *Flow-er de Luc* stand to the Westwards of the true North point of the *Horizon*, we say that *Variation* is towards the left hand; forasmuch as not only the North point, but all the other points of the *Compass*, Rand more towards the left hand than they would do, if there were no *Variation*: This being premised, we come to give *Examples* of the two Rules before-going.

1. Let the *Magnetical Rumb* or Point of the *Compass* be North-east, and the *Variation* 10 degrees to the Eastwards; I demand the true *Rumb*?

Here the *Rumb* and *Variation* are both one way; that is, both towards the right hand; therefore,

To the <i>Magnetical Rumb</i> being N. Easterly	45 deg. 0 m.
Add the <i>Variation</i> Easterly	10 deg. 0 m.
The sum is the true <i>Rumb</i> N. Easterly	55 deg. 0 m.

2. Admit a ship sail upon the North point of the *Compass*, and that the *Variation* be 10 deg. to the Eastwards, how doth she make her way?

The <i>Magnetical Rumb</i> is North, that is,	00 deg. 0 m.
To which adding the Easterly <i>Variation</i>	10 deg. 0 m.
The sum is the angle from the North of the <i>Meridian</i> Eastwards	10 deg. 0 m.

Which is almost *N* by *E*, and so hath the ship made her way.

3. Let the point of the *Compass* be East; point Northerly, that is, from the North to the Eastwards $7\frac{1}{2}$ points, which is 84 deg. 22 min and the *Variation* as before 10 deg. to the Eastwards, I demand the true *Rumb*?

To the <i>Magnetical Rumb</i> being North-east,	84 deg. 22 m.
Add the Easterly <i>Variation</i>	10 deg. 00 m.
The sum is the angle from the North	94 deg. 22 m.
Which subtracted from	180 deg. 00 m.
There rests the true <i>Rumb</i> South-easterly	85 deg. 38 m.

4 Ex-

4 *Example.* Let the Course by the Compass be West and by South, that is, 7 points from the South to the Westwards, or 78 deg. 45 min. and let the Variation be as before 10 deg. to the Eastwards, what is the true Rumb?

To the Magnetical Rumb *S Westerly* 78 deg. 45 min.

Add the *Easterly Variation* 10 deg. 00 min.

The sum is to the true Rumb *S Westerly* 88 deg. 45 min.

You may conceive that the Rumb and Variation are here both one way: namely, both from the Meridian towards the right hand. For the Variation of the North point is from the North towards the East, and consequently of the South point from the South towards the West, both towards the right hand of the Meridian, as the Rumb is.

5 *Example.* Let the Course by the Compass be West, that is, from the South to the Westwards 8 points or 90 degrees, and let the Variation be as before 10 deg. to the Eastwards, I would know the true Course or Rumb?

To the Magnetical Rumb South-west 90 deg. 0 min.

Add to the Variation *Easterly* 10 deg. 0 min.

The sum is the angle to the South } 100 deg. 0 min.
part of the Meridian }

Which subtracted from 180 deg. 0 min.

There rests the true Rumb *N West* 80 deg. 0 min.

Let the Course by the Compass be West, that is, from the North to the Westwards 8 points or 90 degrees, and let the Variation be 10 deg. to the Westwards: I demand the true Rumb?

To the Magnetical Rumb *N West* 90 deg. 0 min.

Add the Variation *Westerly* 10 deg. 0 min.

The sum is 100 deg. 0 min.

Which subtracted from 180 deg. 0 min.

There remains the true Rumb *S West* 80 deg. 0 min.

Object. The Magnetical Rumb being here West 90 deg. why should it not as well be counted from the South as from the North?

Ans. It may be counted from either, for as it is counted here from the North to the Westwards it falls under the first Rule, because

because the Variation is the same way: But if it be reckoned from the South to the Westwards, it falls under the second Rule, where of we now come to give some Examples, supposing these already given sufficient to illustrate the first Rule?

7 *Example.* Let the point of the Compass be N N W and the Variation 10 deg. Easterly, I demand the true Rumb:

From the Magnetical Rumb N W 12 deg. 30 m.

Subtract the Easterly Variation 10 deg. 00 m.

The remainder is the true Rumb N W 12 deg. 30 m.

8 *Example.* Let the point of the Compass be North, and the Variation Easterly 10 deg. what is the true Rumb?

From the Easterly Variation 10 deg. 00 min.

Subtract the Magnetical Rumb N W 00 deg. 00 min.

The remainder is the true Rumb; the other? 10 deg. 00 min.
way, namely N E

Object. The Magnetical Rumb may as well be named North easterly 0 deg. 00 min.

Ans. It may, but then it is subject to the first Rule, as in the second *Example*.

9 *Example.* Let the Course by the Compass be West, that is, from the North to the Westwards 8 points, or 90 degrees, and let the Variation be as before 10 degrees to the Eastwards, what is the true Rumb?

From the Magnetical Rumb N W 90 deg. 00 min.

Subtract the Easterly Variation 10 deg. 00 min.

There rests the true Rumb N W 80 deg. 00 min.

Here the Magnetical Rumb might as well have been South-westerly 90 deg. and so it had fallen under the first Rule, as in the fifth *example*.

10 *Example.* Let the Course by the Compass be West; that is, from the South to the Westwards 8 points or 90 degrees, and let the Variation be 10 deg. to the Westwards, I demand the true Rumb?

From the Magnetical Rumb S W 90 deg. 00 min.

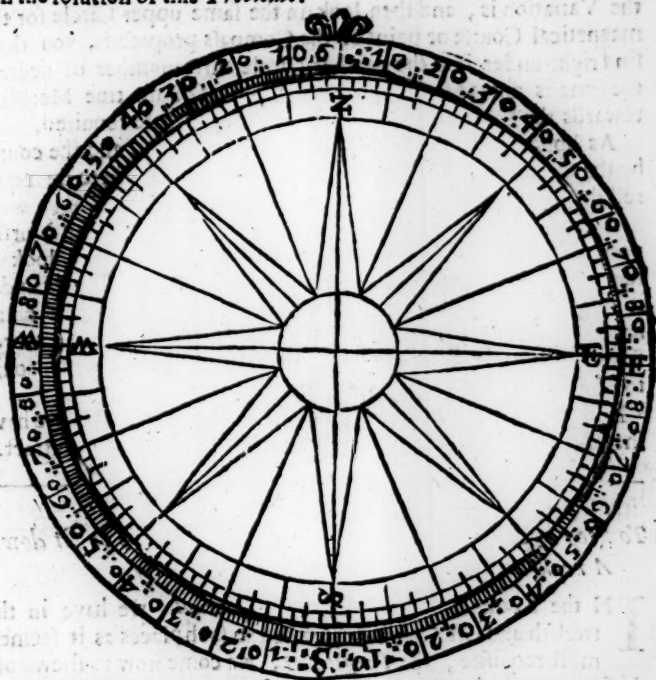
Subtract the Westerly Variation 10 deg. 00 min.

The remainder is the true Rumb S W 80 deg. 00 min.

If

If the Rumb here had been reckoned from the North, as in the sixth *Example*, it had fallen under the first *Rule*.

And this may suffice for the illustration of the two former *Rules* in the solution of this *Probleme*.



The same may also more easily be resolved, by such an *Instrument* as is here described, consisting of two *Circles*, the one being the nethermost divided into four *Quadrants*, and every of those into 90 deg. numbred from the *North* and *South* points, towards the *East* and *West*.

The other being the uppermost and moveable about the *Centre* divided; as the Card of the *Compass* into XXXII *Points*, and those again sub-divided into *halves* and *quarters*.

By this you may readily find the true Rumb for any Course and Variation given.

For if you turn the North point of the upper Circle, from the North point of the lower, so many deg. and the same way that the Variation is, and then look in the same upper Circle for the magnetical Course or point of the Compass proposed, you shall find right under it in the neather Circle what number of degrees the same is distant from the *N.* or *S.* points of the true Meridian towards the *E.* or *W.* which is the true Rumb here required.

As suppose the Variation to be 10 deg. Easterly, and the course by the Compass East half a point Northerly, and there be required the true Rumb ?

I turn the North-point of the upper Circle from the North-point of the lower 10 deg. to the Eastwards, and then I look in the upper Circle, for East half a point Northerly, and right under it in the neather Circle I find 5 deg. and about one half numbered from the South part of the Meridian towards the East, therefore, I conclude that the true Rumb required is from the South towards the East, $85\frac{1}{2}$ degrees and something more.

By this *Instrument* also (if you use the pen only, as before we have shewed) you shall readily see when to add, and when to subtract.

CHAP. XI.

*To keep a reckoning of your Longitude, and so to set down
A reckoning by longitude, and latitude only.*

IN the Example before given of a *Journal*, we have in the twelfth and last Column expressed in such places as it seemed most requisite, the *Longitudes*, we come now to shew how the same may be known, and first,

By the Rumb and Latitudes given: to find the Difference of Longitude.

As *Radius* is in proportion, to the Tangent of the Rumb;
So is the Difference of Latitude in meridional parts.

To the Difference of Longitude in minutes.

As let the Rumb be North-easterly 48 degrees, and suppose a Ship to run upon this Rumb, from the Latitude of 32 degrees 25 min.

min. into the Latitude of 34 deg. 24 min. there is required the difference of Longitude. Here,

The Meridional parts answering to 34 deg. 24 min. 2200

The Meridional parts for 32 25 2058

The difference of Latitude in such parts is 142

Say then, As *Radius* is in proportion

To the Tangent of the Rumb, 48 deg. 0 min. 10.0456

So the difference of Latitude in merid. parts 142 2.1523

To the difference of Longitude in minutes 158 2.1979

These minutes converted into deg. are 2 deg. 38 min. which is the difference of Longitude required, as the same is expressed in the Journal against the 21 of *February*.

And thus sailing upon one and the same Rumb, you may find the difference of Longitude, and so often as you alter your Rumb, so often working by the same Rule, you shall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may also find the Difference of Longitude neer enough at one operation for many several Rumbs and Distances, provided that those Rumbs differ not much one from another. As in the former Journal from the 27 of *February*, till the second of *March*, I sail by several Rumbs and distances from the Latitude of 43 deg. 55 m. into the Latitude of 48 deg. if you would find the difference of Longitude hereto answerable at one operation, it may be done by this Rule;

As the difference of Longitude in miles,

Is to the departure from the Meridian in miles.

So is the difference of Latitude in the meridional parts,

To the difference of Longitude in minutes.

As in that example, the difference of Latitude for all those Courses, as in the North Column appears is 244.

The departure from the Meridian, as there in the East Column appears is 6301.

The merid. parts for the Latitude of 43 deg. 55 min. are 2939

The merid. parts for the Latitude of 48 deg. 0 m. are 3292

Difference of Latitude in meridional parts is 353

R 2 Say

Say then, As the difference of Latitude 2444 *co. ar.* 6.6119
 To the departure from the Meridian 6301 3.7994
 So the difference of Latitude in Merid. parts 353 2.5478
 To the difference of Longitude in minutes, 910 2.9591
 Which reduced into degrees, is 15 deg. 10 min. And added
 to the former Longitude 21 deg. 28 min.
 Gives the present Longitude 36 deg. 38 min. for the 2 of *March*.
 The like may be done for the account from the second of *March*
 to the fifth of the same, &c.

But if your Courses and Distances run, be all neer to one and the same Parallel or Latitude (as in this Journal they are from the 5 of *March* to the 8) and from the 8 to the 10 , then it is sufficient to find what Longitude in that Parallel is answerable to the miles of Easting or Westing, or departure from the Meridian by this Rule.

As the sine complement of the Latitude of that Parallel

Is in proportion to *Radius*;

So is the the number of miles in that Parallel,

To the difference of Longitude in minutes.

As from the 5 of *March* to the 8 . the Latitude was neer 50 deg. the Easterly distance $186\frac{3}{4}$ miles: therefore for the difference of Longitude, say:

As sine complement the Latitude, *s. c.* 50 deg. 0 min. 1919

To *Radius*,

So is the departure from the Meridian 186 8 3.2714

To the difference of Longitude 290 6 3.4633

Thus it appears, the difference of Longitude is almost 291 minutes, which is 4 deg. 51 min. and this added to the Longitude upon the 5 of *March*, namely, to 46 deg. 52 min. the sum is 51 deg. 43 min. the Longitude upon the 8 of *March*: the like might be done for the 10 of *March*.

And though this last Rule be then fittest to be used, when your Course is near East and West, or your difference of Latitude little; yet it may also be used at other times instead of the two former, without any great error, if you take the middle degree of Latitude, or somewhat more, as in the former Example.

The

The Latitude upon the 27 of *February* is 43 deg. 55 min.
 The Latitude upon the second of *March* is 48 deg. 0 min.
 The middle Latitude or somewhat more is 46 deg. 10 min.
 Say then, As sine compl. the latitude *s. c.* 46 deg. 10 m. 1595
 To *Radiu*,

So the Easting or departure from the Meridian 630.1. 3.7994

To the difference of Longitude, 909 7. 3.9589

Which is almost 910 min, or 15 deg. 10 min. as before.

And thus you may in the 12. and last Column of your Journal, set down your Longitude so often as you think it requisite; and so in the two last Columns you shall have the Substance and principal scope of your Reckoning, namely, your Latitudes and Longitudes, which whensoever you desire to set down in *Mer-cators Chart*, or in the *polar Chart*, or in any other, graduated with degrees of Longitude and Latitude, you may readily do it.

As if I would set down the summe of the foresaid Journal from the 19 of *February* to the 10 of *March*, I find against the 10 of *March* the Latitude to be 49 deg. 54 min. and the difference of Longitude 54 deg. 53 min. Therefore in the Latitude of 49 deg. 54 min. I draw an occult Parallel, and reckoning from the *Summer-Islands* towards the East 54 deg. 53 min. I draw by that Longitude an occult Meridian, the intersection of this Meridian with the foresaid Parallel is the Traverse-point, or the point representing the place of the Ship, and the like is to be understood of any other.

This form of keeping and expressing a Reckoning, is (as I conceive) most apt and agreeable (of all others that I have seen or thought upon) to all sorts of *Charts* or *Maps*, and to the *Globe* itself; and to all the kinds or wayes of Sailing, that are or may be used. We will here add some other Propositions which may sometimes be of good and necessary use in it.

The Rumb and Difference of Latitude given: to find by the Table, the distance of the Rumb, and the Departure from the Meridian thereto answerable, &c.

How to find the Northing and Southing, that is, the Distance in Latitude, as the Easting or Westing, that is, the Distance

stance in Longitude or departure from the Meridian of any Rumb, for any distance run upon it we have before shewed, the like operation is in these Propositions following: namely,

2 *The Rumb and distance in Latitude given: to find the distance in the Rumb, and the Easting or Westing.*

3 *The distance and difference in Latitude given: to find the departure from the Meridian and the Rumb.*

4 *The difference in Latitude, and departure from the Meridian given: to find the Course and Distance.*

5 *The Course and Departure from the Meridian given: to find the Difference of Latitude and Distance.*

6 *The Distance and Departure from the Meridian given: to find the Course and difference of Latitude.*

So that with the first before handled, here are six Propositions, and in every of them two things required; and so they become twelve. We will not stand to give examples of them all, but only of those which are most useful, the rest may by them be conceived.

And first, to find the Easting or Westing of any *Rumb* for any difference of Latitude.

Admit a ship run North-easterly 60 deg. (that is, NE by E, and almost half a point Easterly) till she have altered the latitude 42 min. how much is she departed from the Meridian?

I run down the Column under 60 deg. till I find 42 miles, or 420 tenths, and against it in the adjacent Column I find 72 8 tenths, that is almost 73 miles, which is the departure from the Meridian to the Eastwards.

If you would also have the Distance upon the Rumb, it is right against the numbers in the Column of Distances, being in this Example 84 miles.

2 *Example.* But admit she run North-easterly 60 deg. till she alter her Latitude 1 deg. 32 m. what is the Easterly distance?

This 1 deg. 32 min. is 92 miles, or 920 tenths, for which if I look in the Column under 60 deg. I find no 100 500 866 number so great, but the greatest number there 84 420 728 is 500, which subtracted from 920, there remains 420; therefore in that Column under 60 d. 184 920 1594

I look for these two numbers, namely, 500, and 420, and against the first in the adjacent Column I find 866, and against the second 728, which I set against them as above appeareth, and so adding them, I find for this difference of Latitude, the departure from the Meridian to be $159\frac{2}{5}$ miles.

If further you desire the Distance run upon this Rumb, you have it in the Column of Distances, right against the same numbers, as in the example above appeareth, where being added, it amounts to 184 miles.

The Distance and difference in Latitude given: to find the Rumb and departure from the Meridian.

Admit a ship run upon some Rumb between the North and the East 84 miles, and then have altered the Latitude 42 m. the question is, upon what Rumb hath she run, and how many miles is she to the Eastward in Longitude.

I run cross the Table towards the right hand, looking in every first Column of Distances for 84, till I find against it in one of the adjacent Columns 420, at the top of which Column over 420, there is 60 deg. shewing the Rumb to be North-easterly 60 deg. also against 420 in the adjacent Column I find 728, which sheweth the Distance to the Eastwards to be almost 73 miles.

2 *Example.* But if the Distance run be 184 miles, and the difference of latitude 1 deg. 32 min. and there be required the Rumb and Distance to the Eastwards?

Because the Column of Distances extends but to 100 miles, and the Distance here given 184 miles, you may take the half thereof, which is 92 miles, and likewise half of 1 degree 32 min. which is 46 miles, or 460 tenths, and then look, as before, where you find 460 against 92, for there in the top of the Column you shall find the Rumb, which in this Example is 60 deg. shewing that the Rumb is from the North Easterly 60 deg. and in the adjacent Column against 92 and 460, you shall find 797, which doubled (because it is for the half) is 1594, shewing that the departure from the Meridian to the Eastwards is $159\frac{2}{5}$ miles, These and the rest may also be performed by the *Doctrine of plain triangles*, as we have formerly shewed.

CHAP. XII.

Certain Problems touching Currents.

Although the time be already expired which I assigned for this Work, and mine own more urgent occasions call me away: yet seeing it is necessary in Navigation to take notice of Currents, and to make a competent allowance for them: I will briefly set down certain *Problemes*, such as I have sometimes thought upon, whereby a man may the better conceive and judge of that allowance, the rather for that I know not any that hath handled it.

First then, it is to be conceived, that a Ship or other Vessel sailing or rowing where there is a Current hath a compound motion arising of two different Principles; namely, of the Current and Ships way; so that here are three Motions to be considered, namely, two simple, and the third compounded of them. The first simple motion is that of the Current, whereby it moveth, and is apt to move other things that are in it, the same way. The second of the Ship or Boat, as it moveth by wind or Oars, or is apt to be moved, if there were no Current: The third, compounded of them, is the line of the Ships true motion. The first, we call the way, or motion of the Current: the second, the way or simple motion of the Ship: the third, her compound or true way. The two simple motions being either of them according to right lines and uniform (as in the *Problemes* following, we suppose them to be.) The third also, which is composed of them is a right line; For whether the ship sail directly opposite against the Current, or directly with it the same way, or whether the one cross the other at right angles or oblique, yet still either motion being direct and uniform, they both together beget a right lined uniform motion, because the one retaineth to the other one and the same proportion in every point. And according to these grounds we proceed in the *Problemes* following; to determine the proportions of every of these Motions, and the angles which they make one with another.

- 1 *Admit a Current run East 3 miles an hour, and that a ship under sail run West directly against it 6 miles an hour in her simple motion; what is her true or compound motion?*

From the ships simple motion	6 miles
Subtract the Current	3 miles
The remainder is the ships true motion	3 miles

So the ships true way is to the westwards 3 miles an hour.

- 2 *Admit a Current run West 6 miles an hour, and that a ship under sail run directly against it, 5 miles an hour by the Log: what is the ships compound motion, and which way?*

From the Current being the greater	6 miles
Subtract the ships simple motion	5 miles
The remainder is the ships true motion	1 mile

Which 1 mile shews, that the ship by her compound motion falls a-stern, that is, moves to the Westwards 1 miles an hour.

In the Experimental practice of the two former Problems, it may seem that a ship or Boat so ordered, hath also a motion to the right hand, or to the left, but this comes to pass, because it is hard, and in a manner impossible to stem a Tide or Stream so exactly, but that the ship will swerve, (or yaw as they say) either to the one side, or to the other.

- 3 *Admit a Current run East 3 miles an hour, and that the ship also run East 3 miles an hour by the Log, which is the ships true motion?*

To the ships simple motion	3 miles
Add the Current	3 miles
The sum is the ships true motion	6 miles

So the ships compound or true way is East 6 miles an hour.

- 4 *Admit a Current run East two miles an hour, and the ship South 6 miles an hour; what is the ships true motion, and which way?*

In handling of any Art, to avoid circumlocution, there are used terms or words of Art, serving to express briefly the things handled. And forasmuch as this subject hath not been formerly handled, nor the Principles or Grounds thereof laid (so far as I know) we will add a few such terms as may seem most necessary, expressing here what we mean by them.



Let the line AB run from A to the Southwards, and BD from B to the Eastwards, and let AB be in proportion to BD , as 6 to 2, or 3 to 1.

Then doth AB represent the line of the ships simple motion, BD the motion of the Current, and AD the Compound motion of the ship.

And DAB is the angle contained between the line of the ships simple motion, and the line of her compound or true motion, which for brevities sake we will henceforth call the *Angle of Deflection*. Also ADB is the angle contained between the line of the ships compound motion, and the sett or drift of the Current which we will call the

the angle of *Reflection*.

Lastly, ABD is the angle contained between the line of the ships simple motion, and the sett of the Current, which we will call the *Angle of Incidence*.

Then for the Rumb, the Proportion is thus:

As the simple motion	AB 6 miles	co. ar.	9.2219
Is to the Current	BD 2 miles		0.3011
So is Radius			

To the tangent of Deflection: DAB 18 deg. 26 min. 9.5230

So the Rumb upon which the ship makes her way good is south 18 deg. 29 min. Easterly, that is, *SSE* 4 degrees 4 minutes southerly.

2 For the ships true way, or compound motion.

As the sine of the Deflection: DAB 18 deg. 26 min.	0.5000
To the Current	BD 2 miles
So Radius	0.3011

To the true motion AD $6\frac{11}{10}$ 0.8011

So the ships compound motion is $6\frac{11}{10}$ miles hourly, that is, $6\frac{1}{2}$ miles almost.

5 A ship sails West five dayes together by the Log 725 miles, but there is a Current, all this while setting to the Southwards $1\frac{1}{2}$ mile an hour: I demand how she hath sailed, and how far?

The Current setting $1\frac{1}{2}$ mile an hour, sets in 5 dayes 180 miles:
Therefore,

As

As the simple motion AB 725 miles 7.1397
 Is to the Current. DB 180 miles 2.2553
 So is Radius
 To the tangent of Deflection $\angle DAB$ 13 d. 57 m. 9.3950

For the Distance.

As the sine comp. the Deflection $\angle DAB$ 13 d. 57 m. 0.0130
 Is to the simple motion AB 725 min. 2.8603
 So is Radius
 To the compound motion AD , 747 miles 2.8733
 So the ships true Way is West southerly 13 deg. 57 min.
 or South-westerly 76 deg. 3 min. 747 miles.

6 *A ship sails West five days together by the Log 725 miles, in a Current setting to the Southwards; and then finds that he hath altered his Latitude 3 degrees; I demand the motion of the Current, the true Rumb, and true way of the ship?*

This Question differeth little from the former, for seeing the difference of Latitude is 3 deg. the motion of the Current is 180 miles: so there is given the ships simple motion, and the motion of the Current, as before, &c.

7 *A ship in 6 Hours sails from a certain Cape or Head-land South 30 miles by the Log, in a Current setting Easterly, and then observing the same Cape, he finds that it bears NNW ; I demand how fast that Current sets, and how far he hath sailed?*

As let a ship sail from A towards B South 30 miles, but by means of the Current, she is driven more Easterly, namely to D , from whence setting the Cape A , it is found to bear NNW . And seeing the Current sets from B towards D Easterly; therefore the angle of Reflection BDA 6 points, that is, 67 deg. 30 min. Here then is demanded the distance AD , and the drift of the Current in that time BD .

As the sine of the angle of Reflection $\angle BDA$ 67 d. 30 m. .0344
 To the simple motion of the ship AB 30 miles 1.4771
 So the sine of the angle of Deflection $\angle DAB$ 22 d. 30 m. 9.5736
 To the motion of the Current BD 12.16 1.0851
 S 2 And

And further.

As the sine of the angle of Reflection s B D A 67 d. 30 m. 03 44

To the distance run by the Log A B 30 miles.

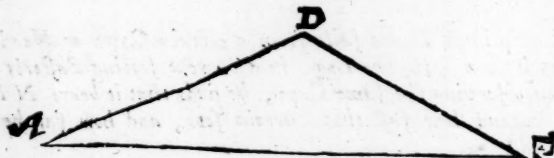
1.4771

So is Radius

To the compound motion of the ship A D, 32 $\frac{47}{100}$ 1.5115And thus we find that Current to set 12 $\frac{47}{100}$; that is, near 12 $\frac{1}{2}$ miles in 6 hours, and the distance run to be 32 $\frac{1}{2}$ miles almost.

That the thing may be better conceived, we will use two or three Examples more familiar and obvious to every mans experience; yet grounded upon the same Principles and Reasons.

- 8 Admit that Tulis-stairs bear from Billingsgate-stairs S. W. Southerly, namely, South-westerly 40 degrees, and be distant 80 Poles: and suppose the tide of Ebb to run there Eastward 2 $\frac{1}{2}$ miles an hour, and that a pair of Oars, rowing 4 $\frac{1}{2}$ miles an hour, would go straight over from the first to the second: how shall they row over, namely, upon what degree or point of the Compass, and how far shall they row to get thither, and in what time?



Let A represent Billingsgate stairs, D Tulis-stairs, A E the simple motion of the Boat, E D the motion of the Current, then is A the angle of Deflection, E the angle of Incidence; D the angle of Reflection 130 deg. or 50 degrees.

As the simple motion of the Boat	A E 4 $\frac{1}{2}$ miles	9.34679
Is to the motion of the tide	D E 2 $\frac{1}{2}$ miles	0.39794
So the sine of Reflection	D s 50 deg.	9.88425
To the sine of Deflection	A s 23 d. 3 m.	9.62898

Thus then the position, from A to D, being south-westerly 40 deg.

deg. and the angle of Deflection A 23 deg. 3 min. the position from A towards E, is South-westerly 63 deg. 3 min. that is. W S W Southerly. And so must those Oars row to go straight over.

Secondly, for the distance A E.

From the angle of Reflection	D	50 deg. 00 min.
Subtract the angle of Deflection	A	23 deg. 03 min.
And there rests the angle of Incidence	E	26 deg. 57 min.

As the sine of Incidence	s E 26 d. 57	0.34370
Is to the true distance	A D 80 poles	1.90309
So the sine of Reflection	s D 50 deg. 0 min.	9.88425
To the simple motion	A E 135 $\frac{1}{10}$ poles	2.13104

Lastly, for the time, seeing 320 Poles make a mile, and they row $4\frac{1}{2}$ miles an hour: it is 1440 Poles in an hour: so the proportion is,

As the simple hourly motion	1440	6.8416
To the simple motion before found	135 $\frac{1}{10}$	2.1310
So is an hour in minutes, namely,	60 min.	1.7781
To the time required in minutes	5 $\frac{63}{100}$	0.7507

• And so long will they be rowing.

9 But suppose they will row harder, to go a shorter cut; namely, to go South-west by West, how fast must they go to row straight over, and how far, and in what time?

Then seeing the Position from A to D is South-westerly 40 deg. and S W by W is South-westerly 56 deg. 15 min. therefore the angle of Deflection at A is 16 deg. 15 min. the angle of Reflection D as before, 50 deg. 0 min. the angle of Incidence E is 33 deg. 45 min.

As the sine of Deflection	s A 16 deg. 15 min.	.55311
To the motion of the tide	D E 2 $\frac{1}{2}$ miles	0.39794
So the sine of the angle of Reflection	D 50 deg. 0 min.	9.88425
To the simple hourly motion of the Boat	A E 6 $\frac{144}{100}$	0.83530

And such is the hourly motion of the Boat, namely. 6 $\frac{144}{100}$ miles in an hour.

Secondly,

Secondly, for the simple motion,

As the sine of Incidence	s E 33 d. 45 m.	0.25526
Is to the true distance	A D 80 Poles	1.90309
So the sine of Reflection	D 50 deg. 0 min.	988425
To the simple motion	A E 100.5 poles	2.04260

Thus it appears they must row 110.5 poles to get over.

*Lastly, for the time.*The hourly motion before found $6\frac{844}{1000}$ reduced into Poles, is 2190.

As the simple hourly motion	2190	6.65956
Is in proportion to an hour, or	60 min.	1.77815
So is the simple motion before found	110.5	2.04260
To the time required	$3\frac{011}{1000}$ min.	0.48031

And so long will they be rowing over.

10 But admit a Sculler rowing three miles an hour, would 'cross straight over at the same time, upon what point must he row, and how far to get thither, and in what time will he do it?

First, for the angle of Position.

As the hourly motion of the Boat A E 3 miles	9.52288
To the sine of Reflection D 50 deg.	9.88425
So is the hourly motion of the Stream D E 2.5 min.	0.39794
To the sine of Deflection A s 39 d. 40 m.	9.80507

Now seeing the position for *Bilingsgate* to *Talis-stairs*, namely from A to D, is by supposition to the Westwards of the South 40 deg. and the angle of Deflection A is here found to be 39 deg. 40 min. therefore the position from A to E is from the South to the Westwards 79 deg. 40 m. which is West and by South, and almost 1 deg. Westerly, and so must that Sculler row to go straight over.

Secondly, for the distance A E

From the angle of Reflection D	50 deg. 00 min.
Subtracting the angle of Deflection A	39 deg. 40 min.

And there rests the angle of Incidence E 10 deg. 20 min.

As the sine of Incidence	s E 10 deg. 20 min.	.74624
To the true distance	A D 80 poles	1.90309
So is the sine of Reflection D 50 deg. 0 min.		9.88425
To the simple motion	A E 341.5 p.	2.53338

And

And thus it appears, that though the distance of the two places be but 80 Poles, yet if according to the question, he row but after three miles an hour, and the stream set after $2\frac{1}{2}$ miles an hour, then he must row $341\frac{1}{16}$ poles to go straight over.

Lastly, for the time.

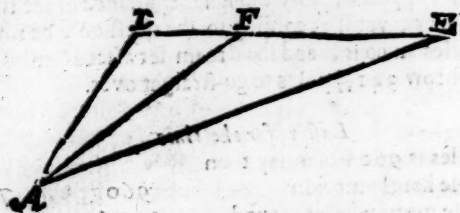
Three miles is 960 Poles, say then		
As the simple hourly motion	960	7.01773
To the simple motion before found	$341\frac{1}{16}$	2.53358
So is an hour in minutes, namely,	60 min.	1.77815
To the time required in minutes	$21\frac{35}{100}$	1.32946

And thus it appears that the time requisite to row over, rowing 3 miles an hour; is $21\frac{35}{100}$ minutes, whereas we found before, that rowing there $4\frac{1}{2}$ miles an hour, they might row over in $5\frac{9}{100}$ minutes, which is little more than a fourth part of the time.

There might be other and that great variety of Questions of this nature proposed and resolved, many of good use in practice, which the Water-men by daily experience without other Rules, are able to guess at something neerly, sufficing for their occasions: my intent in these especially to explicate the Compound motion of a Ship or other Vessel sailing or rowing where there is a Current; which by such familiar Examples may seem more evident. I cannot insist upon them by reason of mine other occasions, nor spend that time in these here handled, which else I should have done; whence if any defect or mistake should arise, if the Reader be pleased to give me friendly notice of it, I shall as thankfully accept it, and reform it; We propose next a question at Sea, which let be this.

- 11 There is a Current at Sea setting East 12 miles in 24 hours, a ship sails in the same from a certain Port West South-west 6 dayes, and then returning thence, and sailing NE by North 3 dayes, falls with the Port from whence he first departed, I demand what his dead Reckoning was outwards, and what back again, and how far these two Ports were asunder, and upon what point of the Compass?

As



As let the Current set from E towards D, and let the first Port be A, the second F, and let the Course outward bound be represented by A E, and the Course homewards by D A, &c.

And forasmuch as D E is an East and West line and A E West-south-west, therefore the angle at E is 22 deg. 30 min. and by the like reason, the angle at D is 123 deg. 45 min. or 56 deg. 15 min. and the angle at A 33 deg. 45 min. and E D being the setting of the Current for 9 days, is 108 miles.

First then, for the dead Reckoning outward, namely A E.

As the sine of the angle at A	33 deg. 45 min.	.25526
To the line D E	108 miles	2.03341
So is the sine of the angle at D	56 deg. 15 min.	9.91985
To the line A E	161. ⁴ / ₅	2.2083

Thus A E his dead Reckoning outwards is 161.⁴/₅

Secondly, for A D.

As the sine of the angle D A E	33 deg. 45 min.	.25526
Is to the line D E	108 miles	2.03342
So is the sine of the angle D E A	22 deg. 30 min.	9.58084
To the line A D	74. ⁴ / ₅ miles	1.87152

Which 74.⁴/₅ miles is his dead Reckoning homewards.

Thirdly, for the angle D A F or D F A.

To the side A D is found	74. ⁴ / ₅ miles.
The side D F for 3 dayes, is	36 miles.
The sum of both is	110. ⁴ / ₅
Their Difference is	38. ⁴ / ₅

The sum of the angles D A F and D F A

56 deg. 15 m.

The half sum is

28 deg. 7¹/₂ m.

The

The Proportion.

As the sum of the sides	110 $\frac{1}{2}$	7.95703
Is to their difference	38 $\frac{1}{2}$	2.58433
So is the tangent of	28 deg. 07 $\frac{1}{2}$	9.72706
To the tangent of	10 deg. 32 m.	9.26932

Which added together, make the angle D F A 38 deg. 39 $\frac{1}{2}$.
 And seeing the Rumb from F to D is East, and the angle DFA 38 deg. 39 m., therefore the Rumb from F to A is to the Northwards of the East 38 deg. 39 m., that is NE by E almost half a point Northerly, which is the Rumb from the second port to the first.

Lastly, for A F, the distance of these two ports.

As the sine of the angle D F A, 38 deg. 39 $\frac{1}{2}$	20434
To the dead reckoning	
homewards	A D 74 $\frac{1}{2}$ miles
So is the sine of the angle D s 56 deg. 15 min.	9.91985
To the distance	A F 99 $\frac{1}{2}$ miles
	1.99571

Thus the true distance of those two ports is 99 miles, and somewhat more.

Sundry other questions of like nature might be proposed, which to him that understandeth, well these will not be difficult.

These principles a little enlarged may further with a few Experiments be applyed in the discovery of some mysteries in compound motions not yet divulged, though much endeavoured by sundry famous men in several parts of Europe; but these we shall not touch at present.

12 To find where there is a Current at Sea, also which way it sets, and how fast.

This may be done by comparing the reckoning outwards with the reckoning homewards, whereof we will give an Example or two.

First, admit a ship sail from a certain Port, by one or several Rumbs or Distances, till she arrive at a second, and there find reckoning by Course and Distance; that she is more Southerly, than the Port from which she departed by 541 miles, and more Westerly by 145 miles: But by his Reckoning homewards,

T

when

when he arrives again at the first place, he finds himself to the Northwards of the second 341 miles, as before, and to the Eastwards 305 miles. Now supposing he were three dayes outwards bound, and five dayes homewards bound, I would know which way the Current sets, and how fast? Here because the Easterly distance homewards is greater than the Westerly distance outwards; therefore from the Easterly distance 305 miles, subtract the Westerly distance 145 miles, the remainder being 160 miles, is the motion of the Current to the Westwards.

And thus it appears, that that Current sets to the Westwards, 160 miles in eight dayes, that is, 20 miles a day, or $\frac{1}{2}$ of a mile every hour.

Example. Admit a ship sail from the *Summer-Islands*, by several Rumbes and Distances, till she arrive at Cape *Codd* in *New-England*, namely, from the East part of the *Summer-Islands* (the Variation being allowed) first, North 20 miles, and then NNW 150 miles, the second day N by W 180 miles: the

	North	South	East	West
North 20 miles	20 0			
North N W 150 miles	138 6			57 4
North by W 180 miles	176 5			35 1
North 90 miles	90 0			
North-east 88 miles	62 2		62 2	
528 miles	487 3		62 2	92 5
				62 2
				30 3

third day North 90 miles, the fourth day NE 88 miles, and so arrive at Cape *Codd*: then by these Courses and Distances we may gather by the fore-going Table, that Cape *Codd* should by this Reckoning be to the Northwards 487 miles; and to the Westwards 30 miles, as here appears.

Now suppose she sail back again from Cape *Codd* towards the *Summer-Islands*, the first day SSW 150 miles: the second day

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day S S W 160 miles; the third day S by W 130 miles; the fourth day South 140 miles; the fifth day East 110 miles, and so be come again to the East part of the *Summer-Islands*.

	North	South	East	West
South S W 150 miles	—	138.6	—	57. 4
South S W 160 miles	—	147.8	—	61. 3
South by W 130 miles	—	127.9	—	25. 3
South 140 miles	—	140.0	—	—
East 110 miles	—	—	110.0	—
690 miles	—	554.0	110.0	144.0
				110.0
				34. 0

These Courses and Distances make, as here appeareth, the *Summer-Islands* to be to the southwards of Cape Codd 554 miles, and to the Westwards 30 miles.

Therefore by this last Reckoning back again Cape Codd should be to the Northwards of the *Summer-Islands* 554 miles, and to the Eastwards 34 miles, whereas by the former reckonings outwards, it was to the Northwards only 487 miles, and to the Westwards 30 miles; so that the difference of these two reckonings outwards and back again is 67 miles Northerly, and 64 miles Easterly, which sheweth that the Current in that time, namely, in 9 days, hath set to the Northwards 67 miles, and to the Eastwards 64 miles; that is, North-east little Northerly 93 miles, as by the fore-going Table doth appear, which is 10 $\frac{1}{2}$ miles every day.

And what we have here done by the Tables might have been done (as the fore-going Problemes) by the Doctrine of plain Triangles.

F I N I S.

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Corner, near London Bridge.*

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